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Wang et al.

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(54) **SPECTROMETER, ASSEMBLING METHOD THEREOF, AND ASSEMBLING SYSTEM**

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G01J 3/02 (2006.01)
G01J 3/18 (2006.01)

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CPC G01J 3/0259; G01J 3/029; G01J 3/18; G01J 3/02

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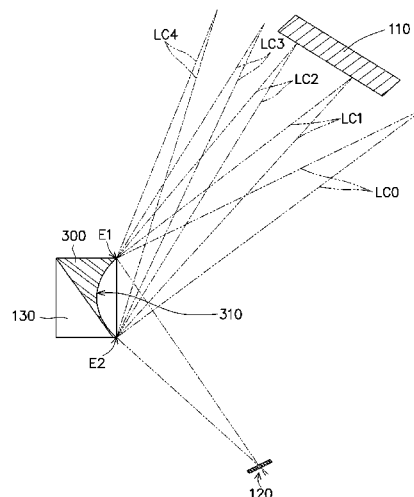
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(57) **ABSTRACT**

A spectrometer comprising a waveguide module, a diffractive component, and a light sensor is provided. The waveguide module has a first reflective surface, a second reflective surface opposite to the first reflective surface, and a light channel between the first reflective surface and the second reflective surface. The diffractive component has a diffractive surface and a plurality of strip-shaped diffractive structures located on the diffractive surface. The sharpness of the profile of the strip-shaped diffractive structures on a first side of the diffractive surface is greater than that on a second side of the diffractive surface. When viewed along a direction perpendicular to the second reflective surface, the first side of the diffractive surface is positioned between the first reflective surface and the second reflective surface with a distance away from the second reflective surface. A method for assembling the spectrometer and an assembling system are also provided.

31 Claims, 25 Drawing Sheets



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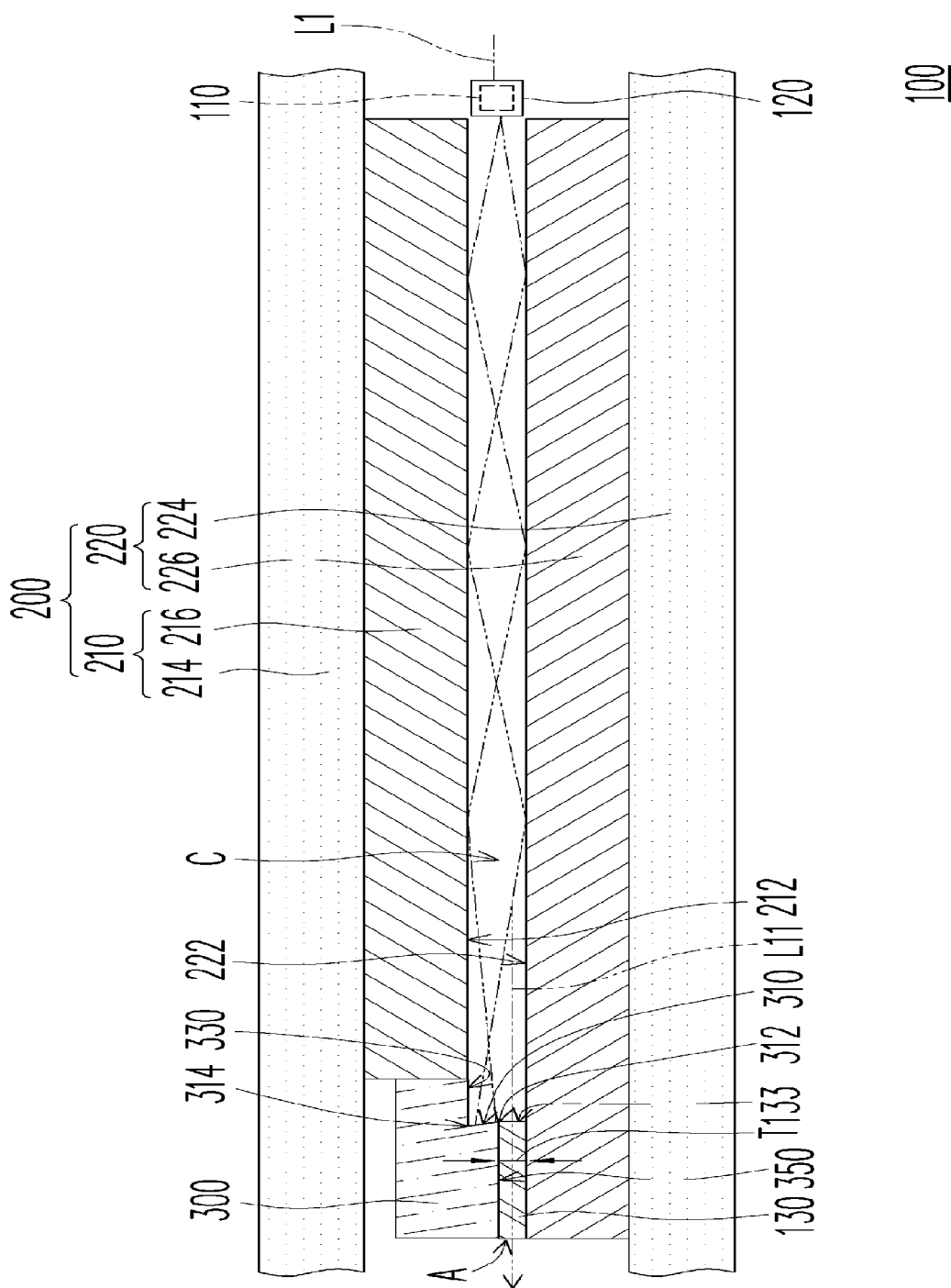


FIGURE 1A

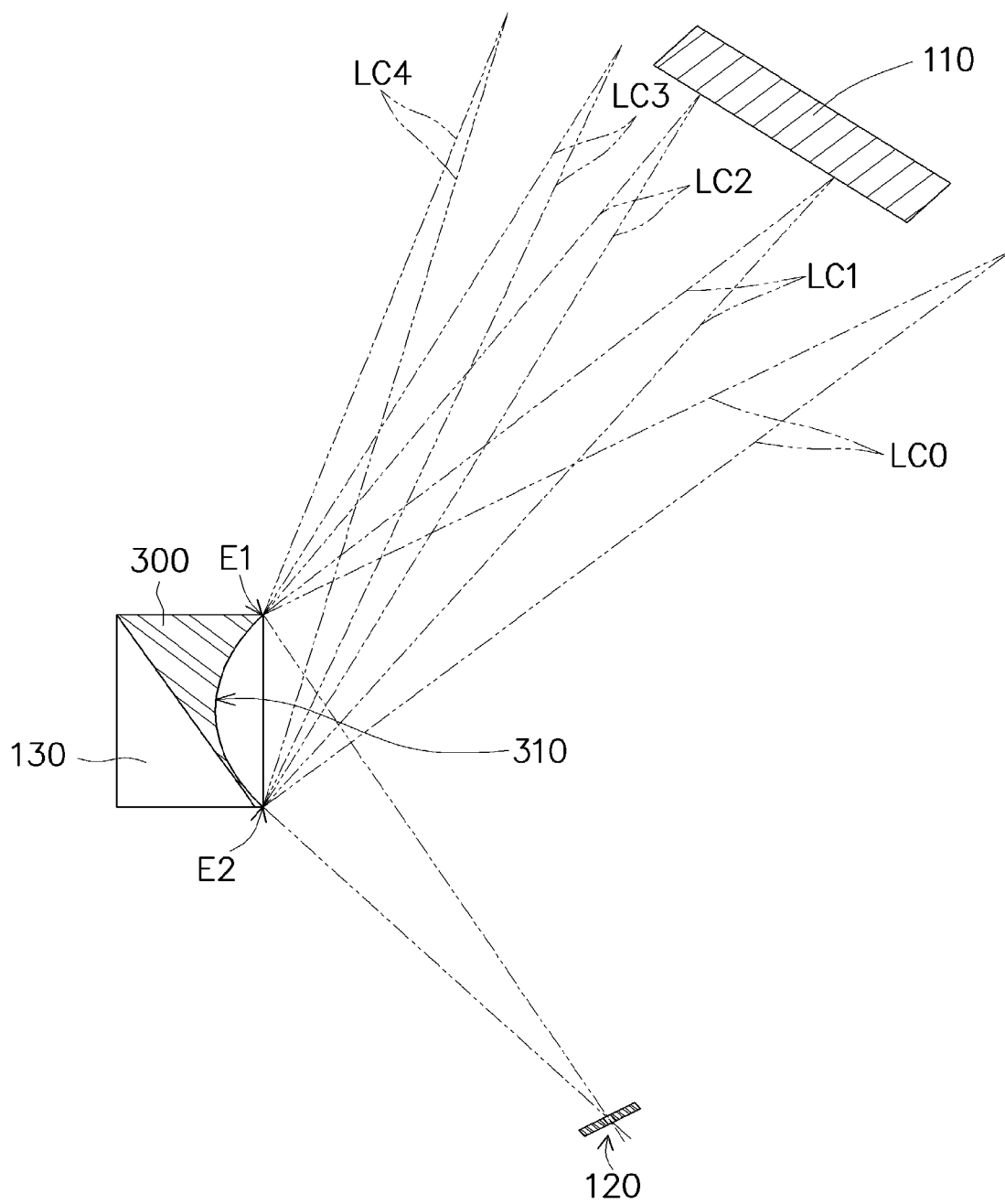


FIGURE 1B

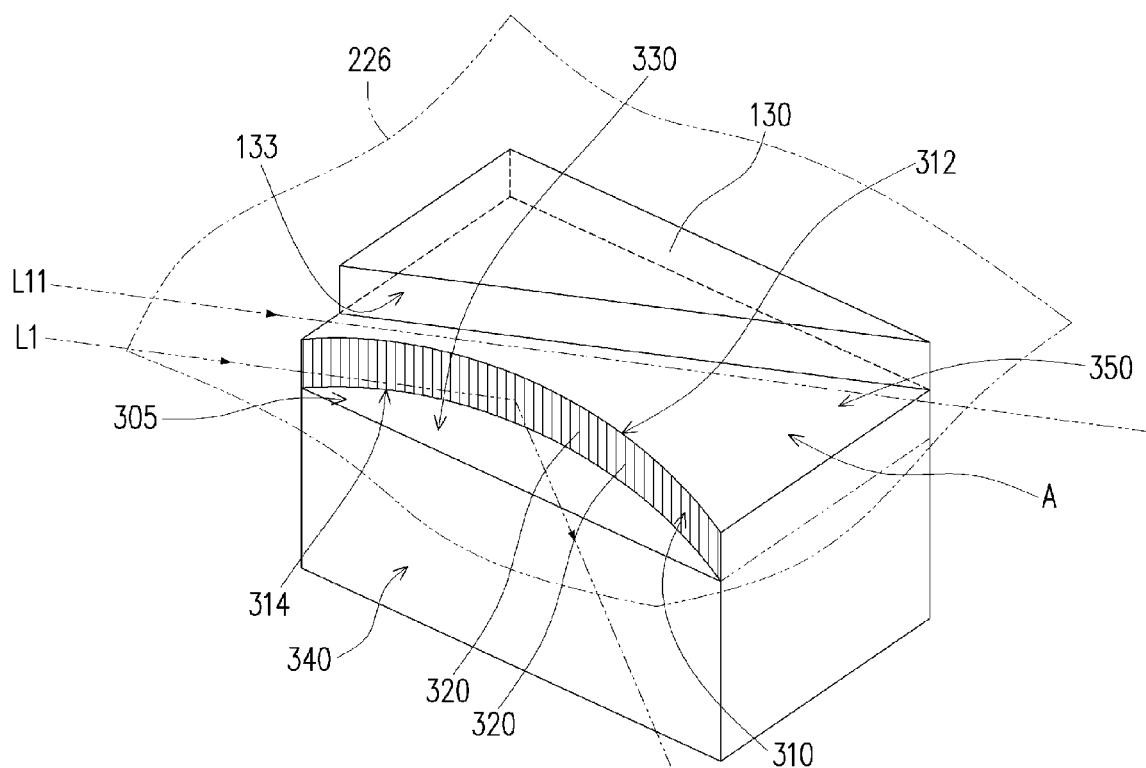
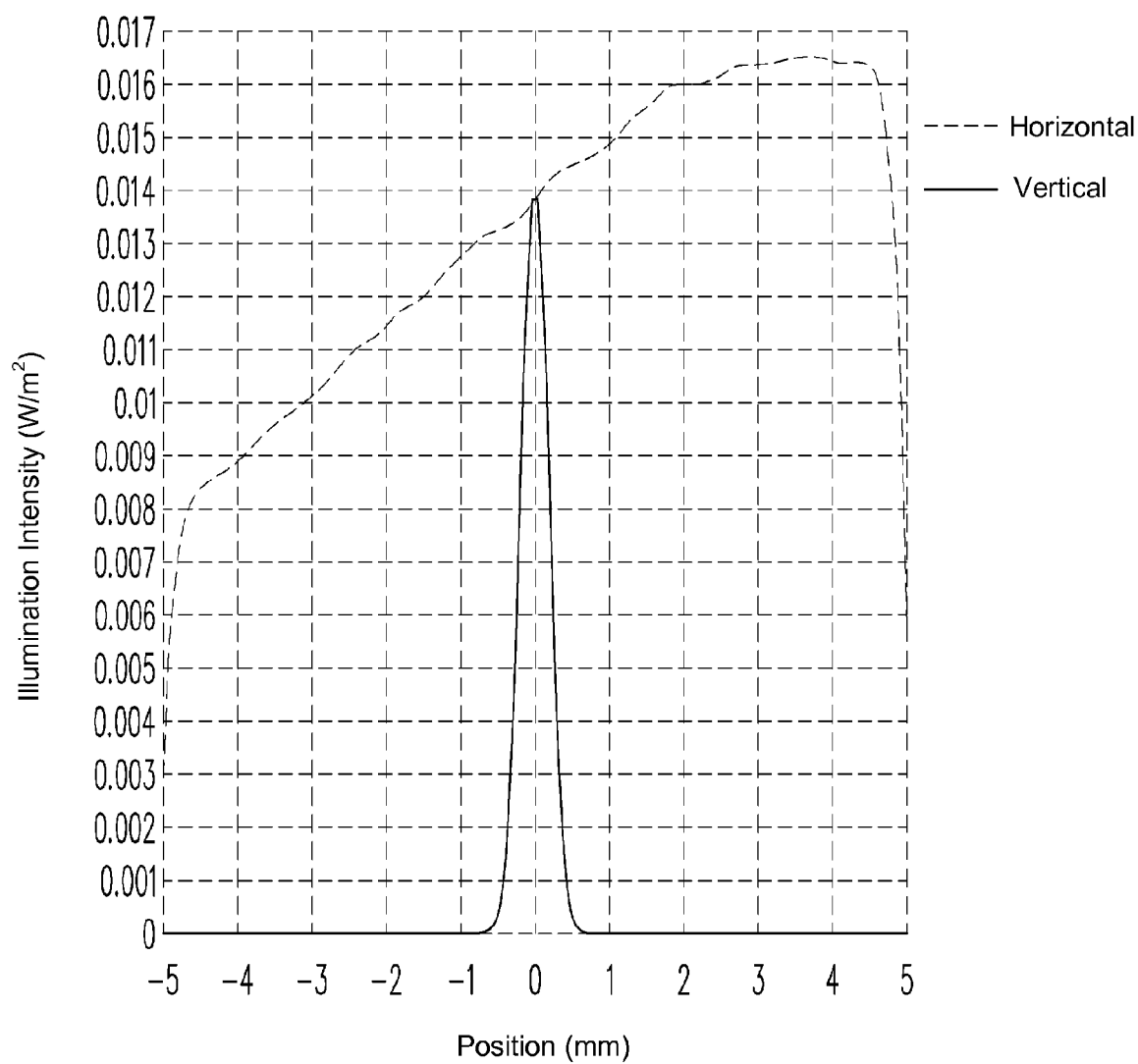


FIGURE 1C

**FIGURE 2**

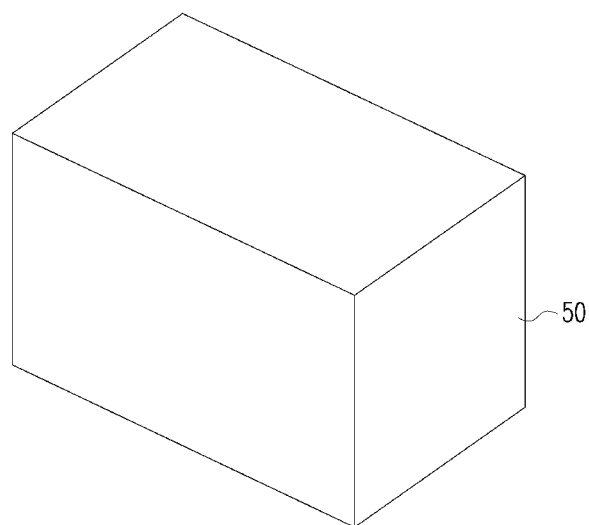


FIGURE 3A

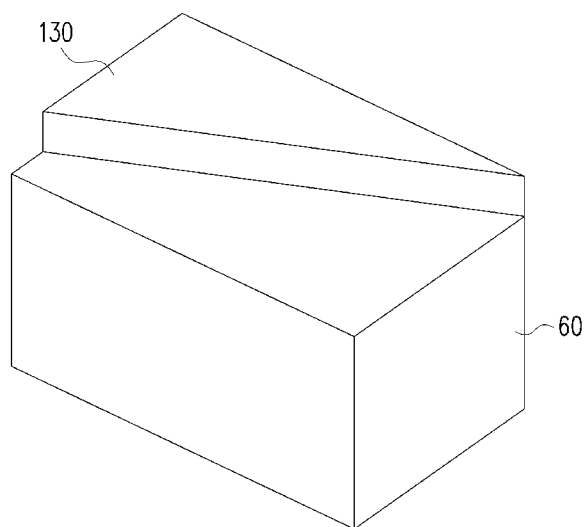


FIGURE 3B

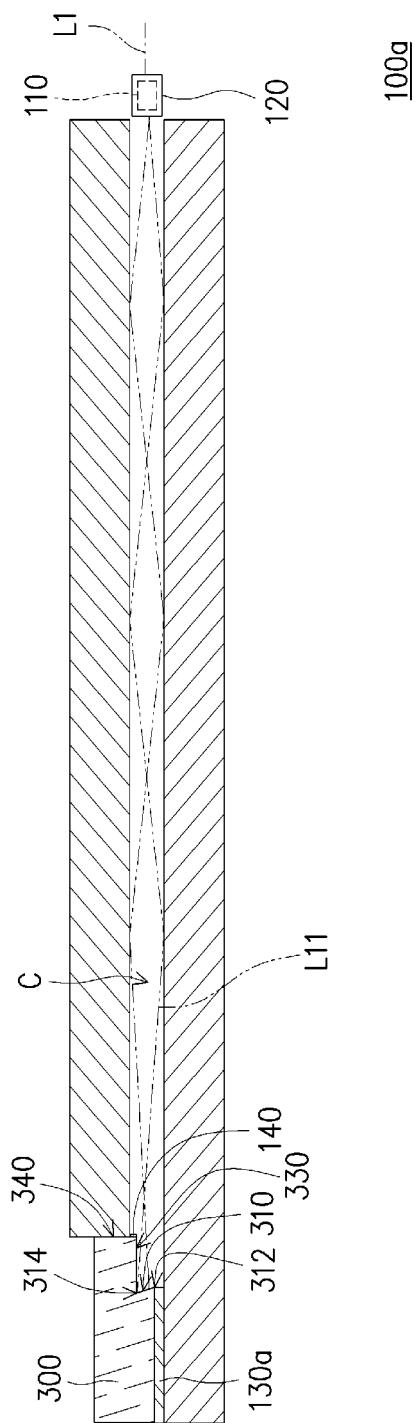
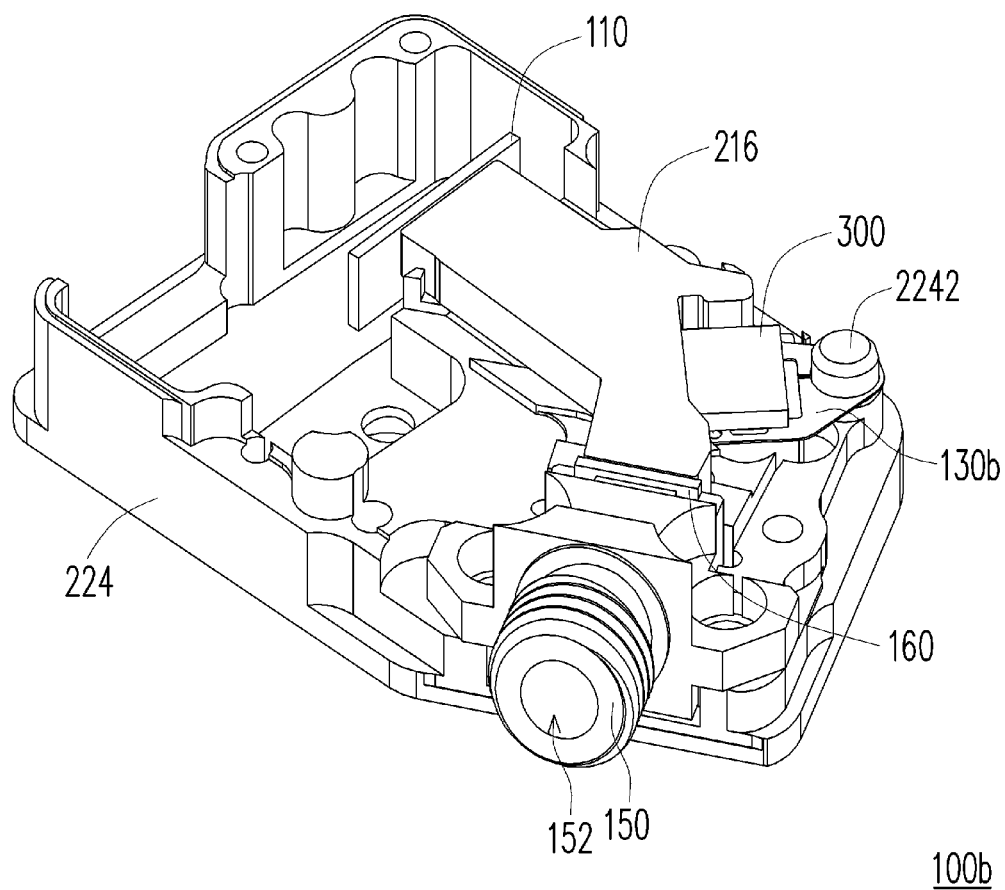


FIGURE 4

**FIGURE 5A**

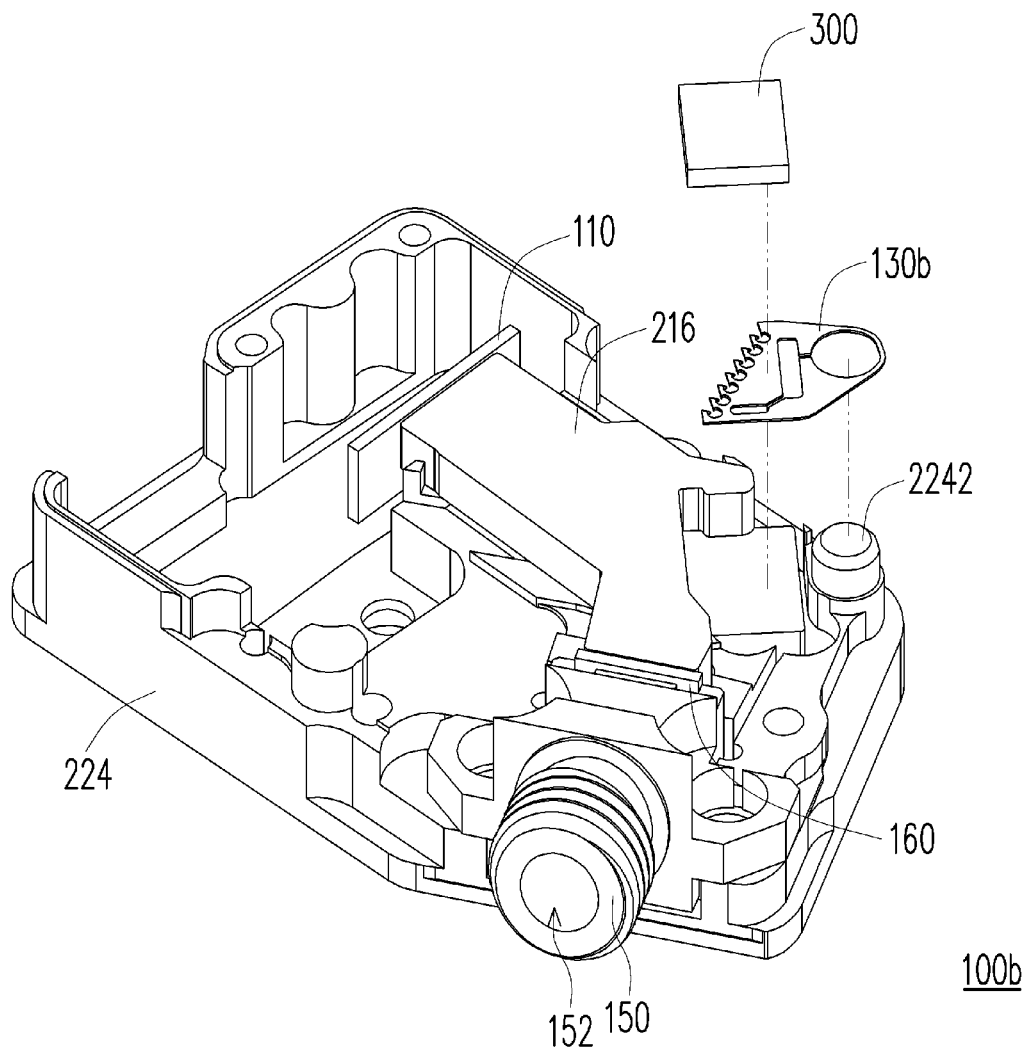


FIGURE 5B

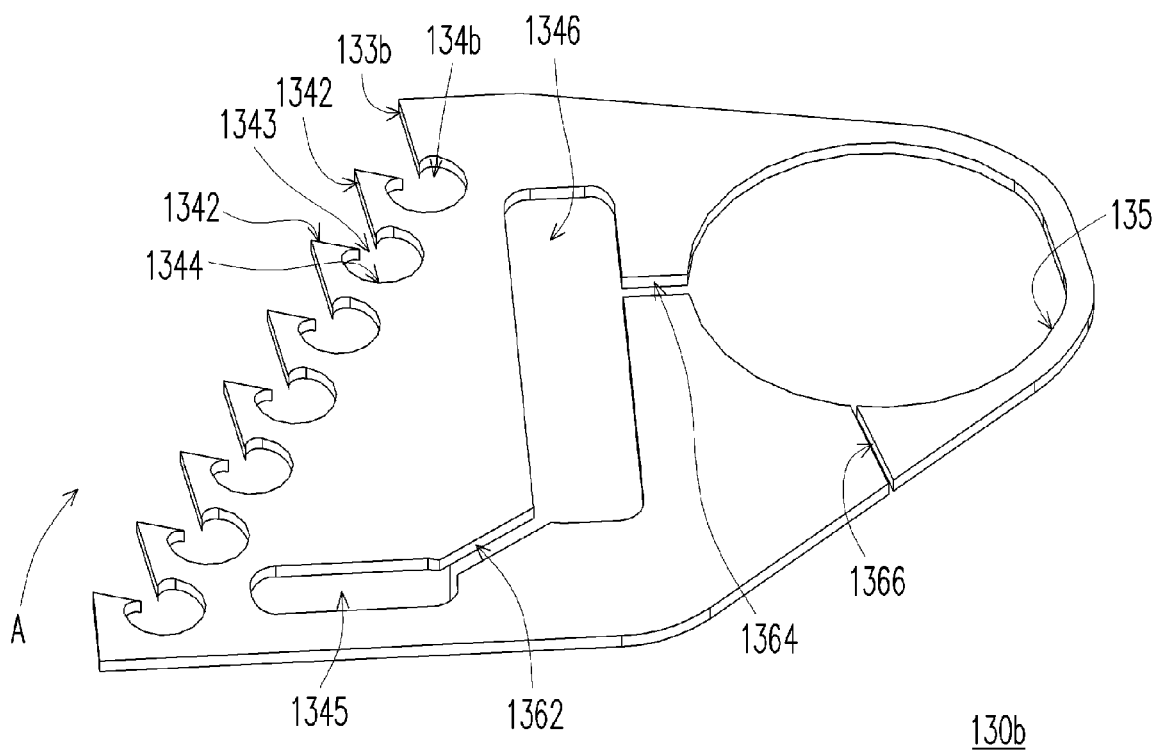


FIGURE 5C

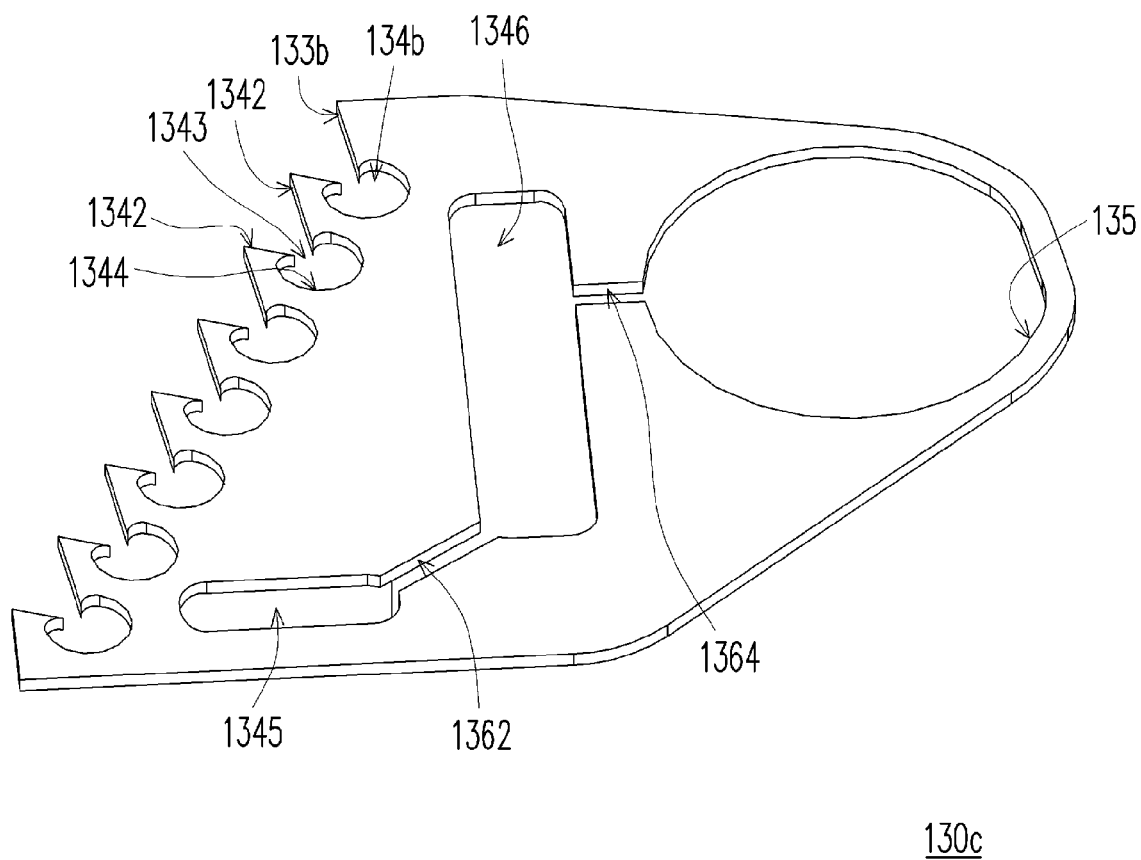


FIGURE 6

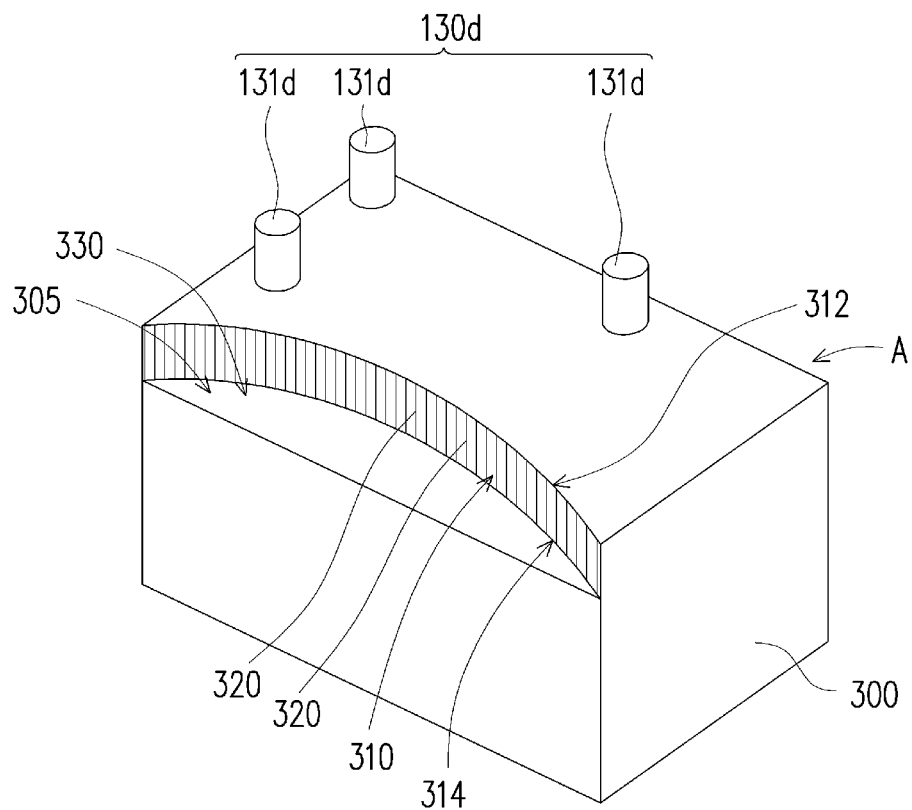


FIGURE 7

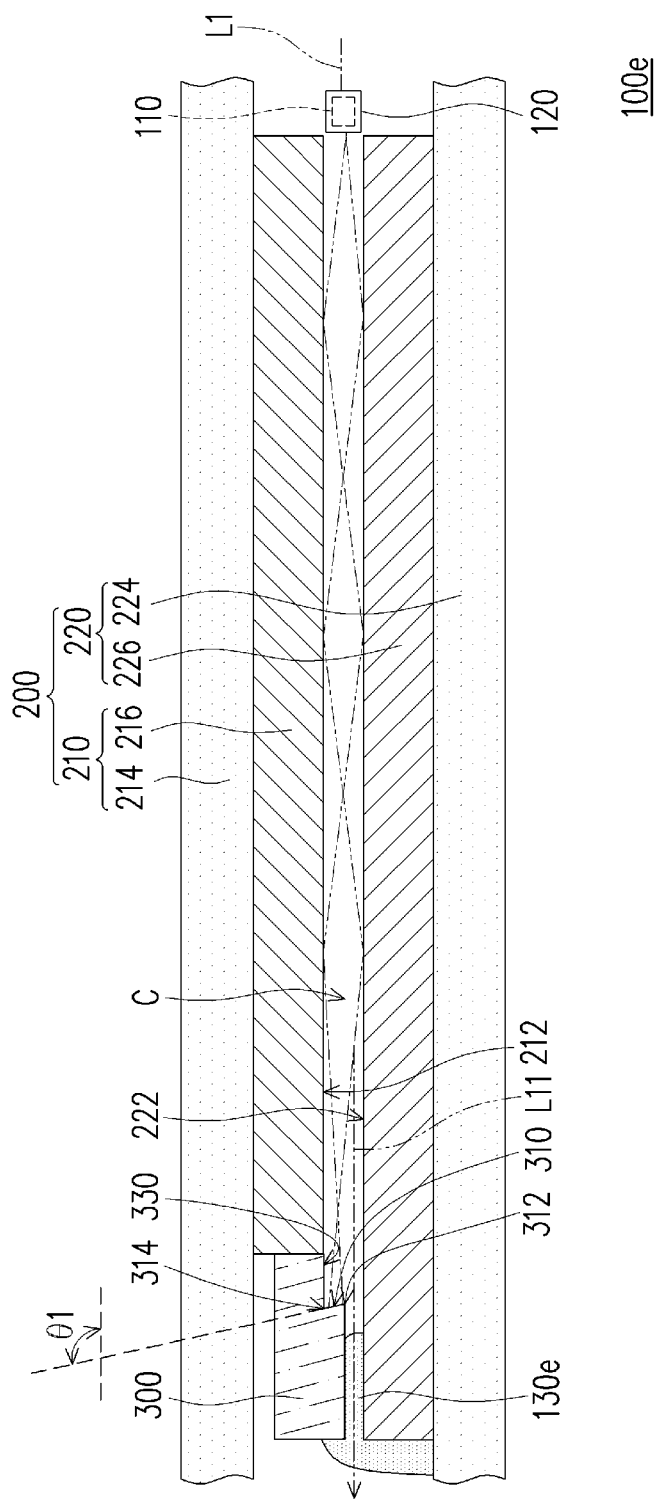


FIGURE 8

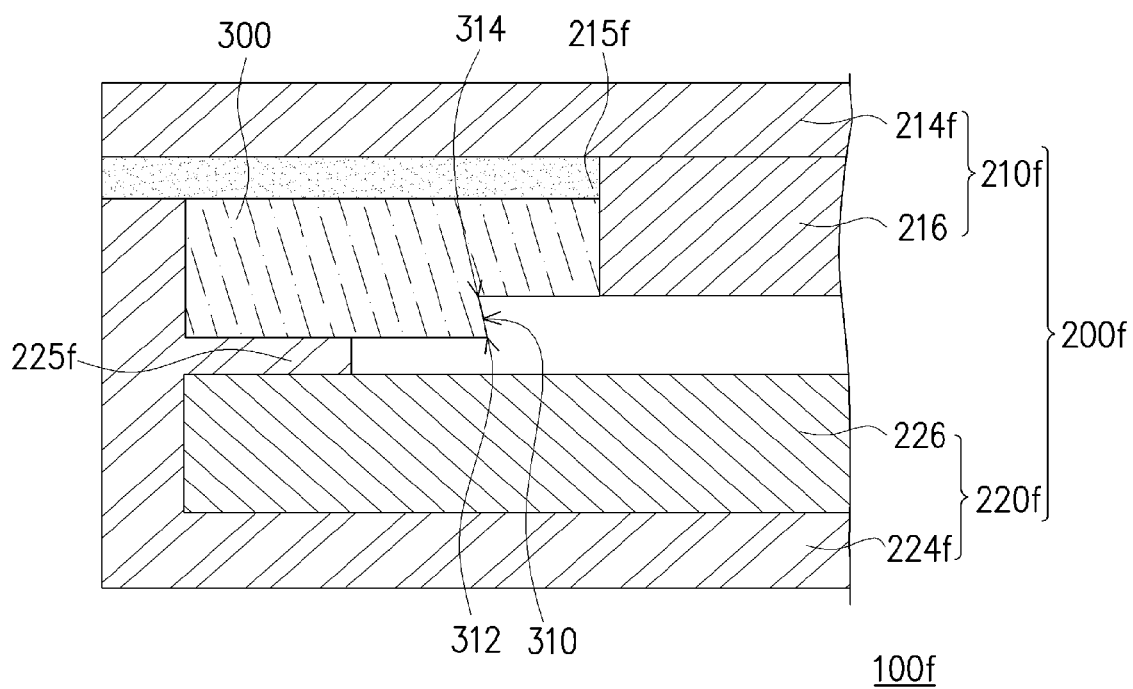


FIGURE 9

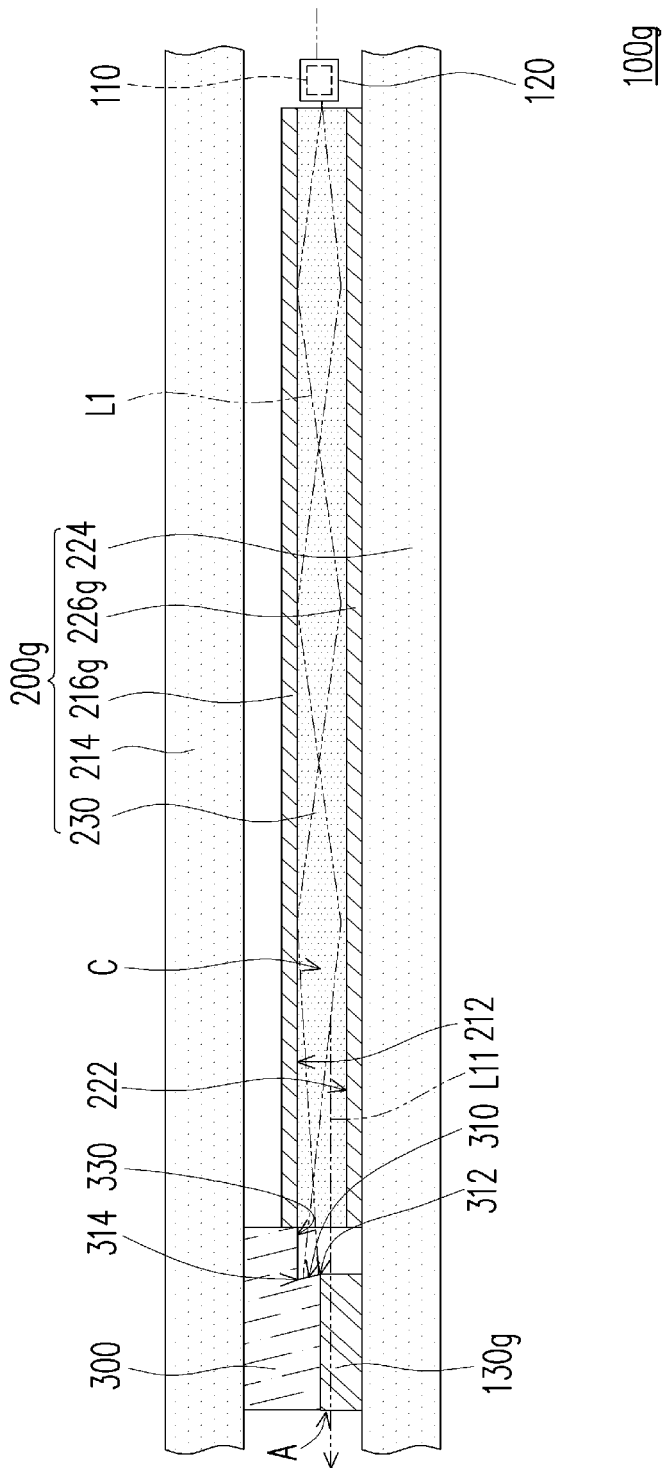


FIGURE 10

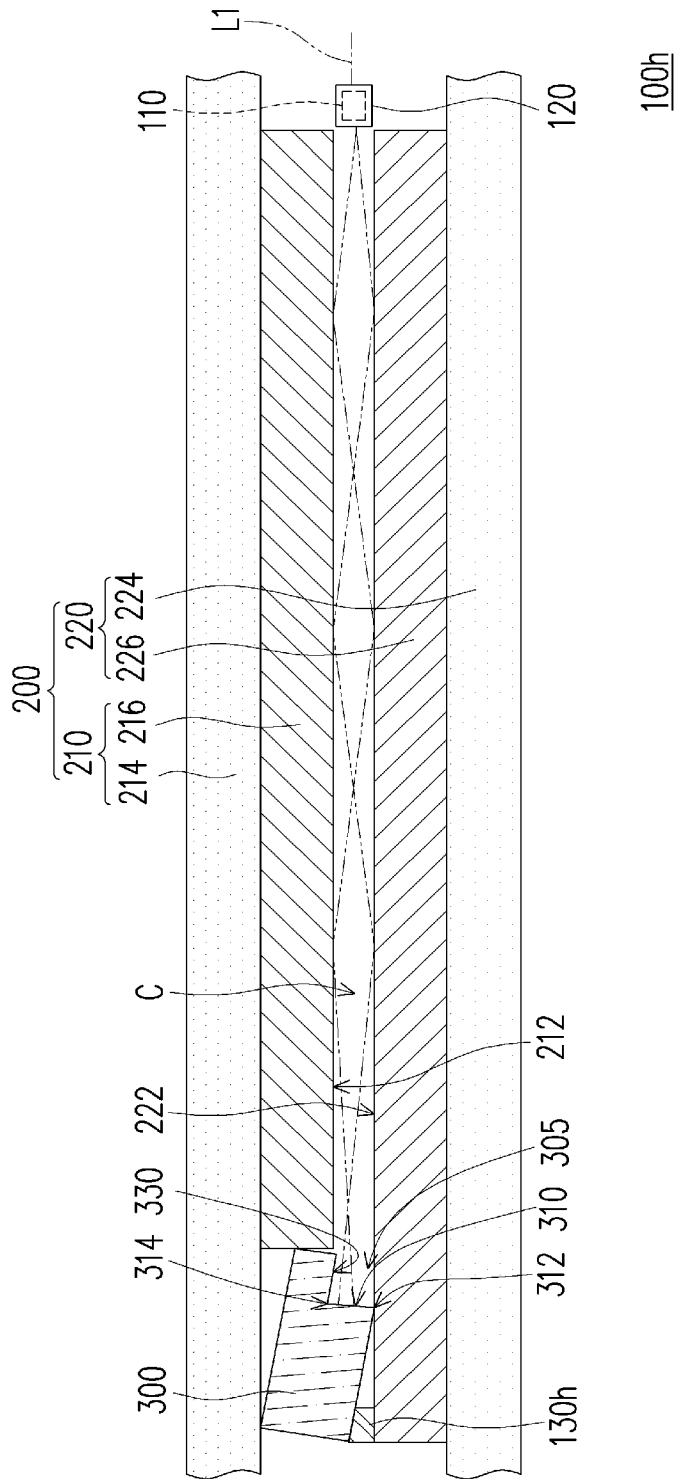


FIGURE 11

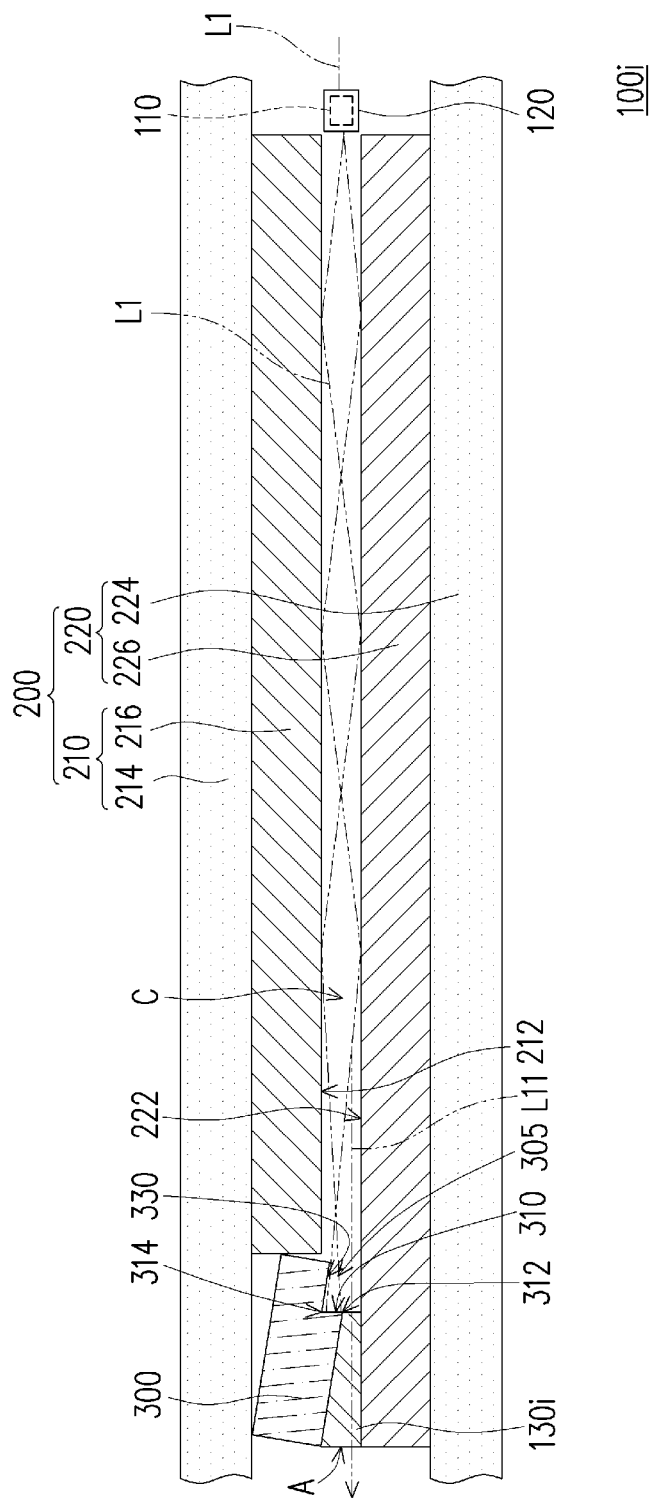


FIGURE 12

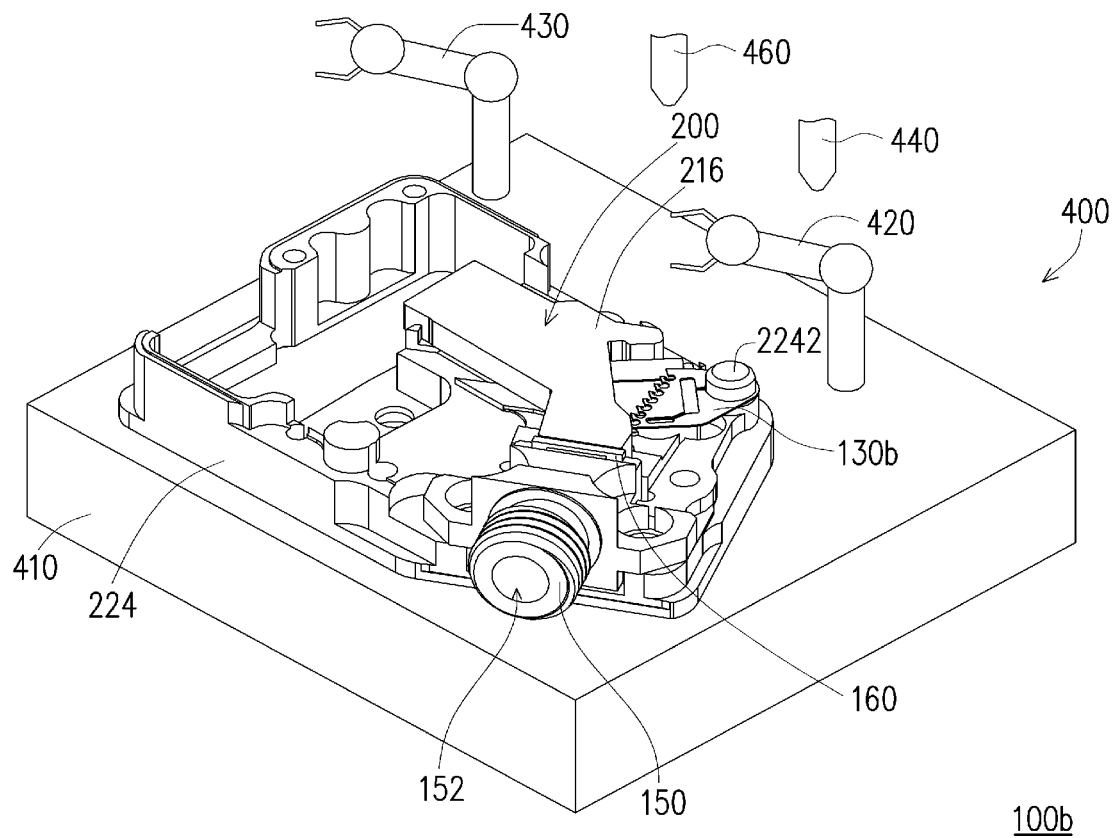


FIGURE 13A

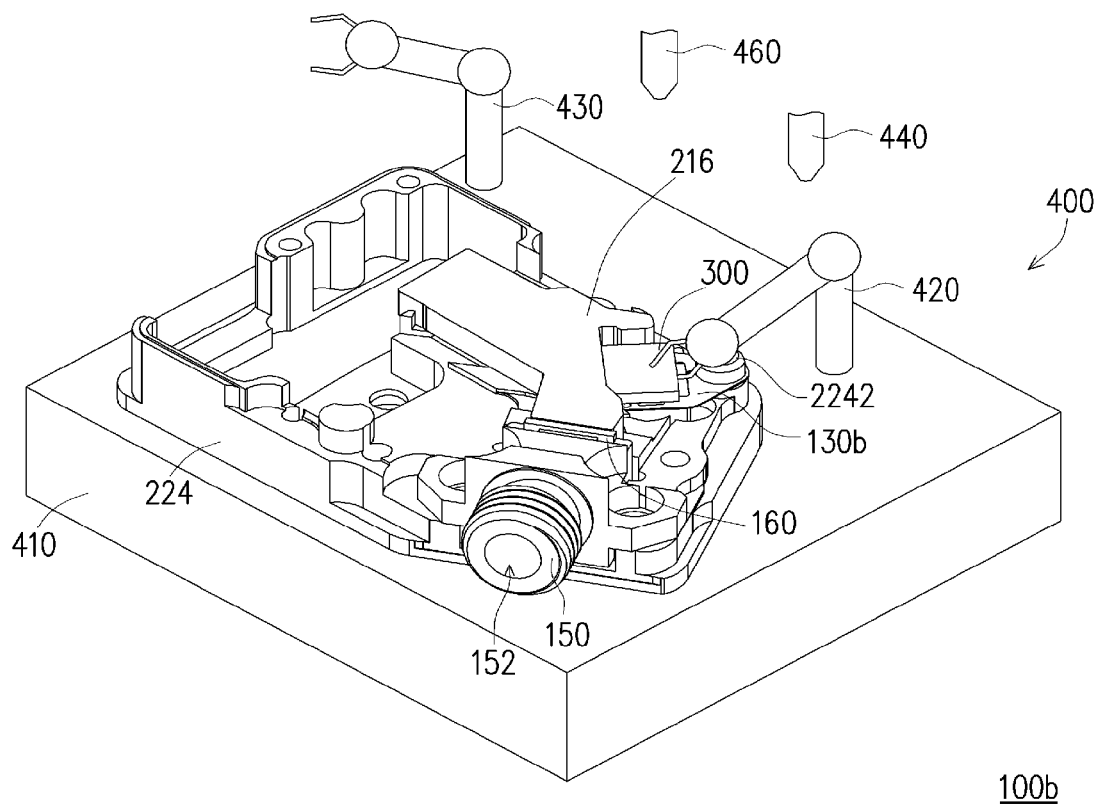


FIGURE 13B

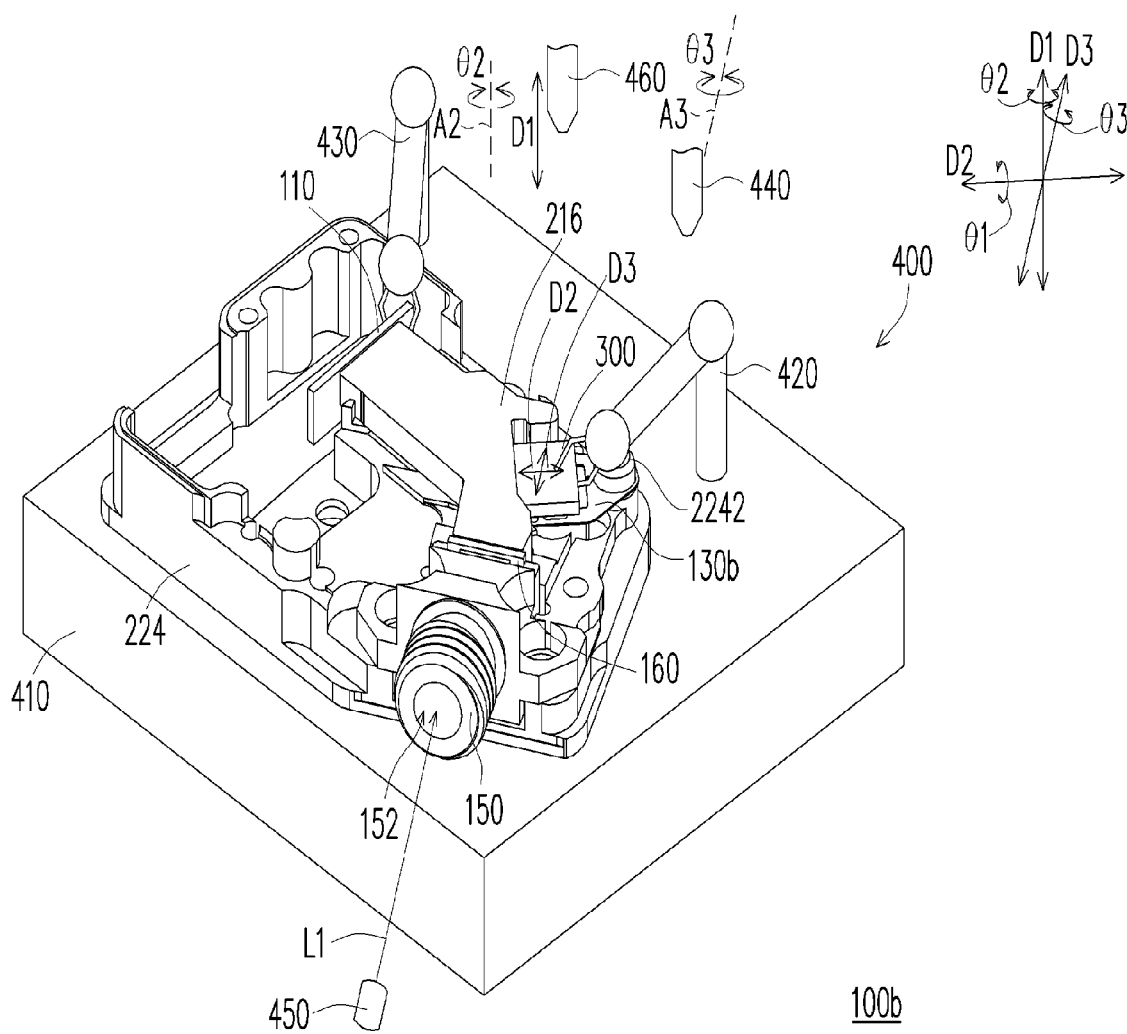


FIGURE 13C

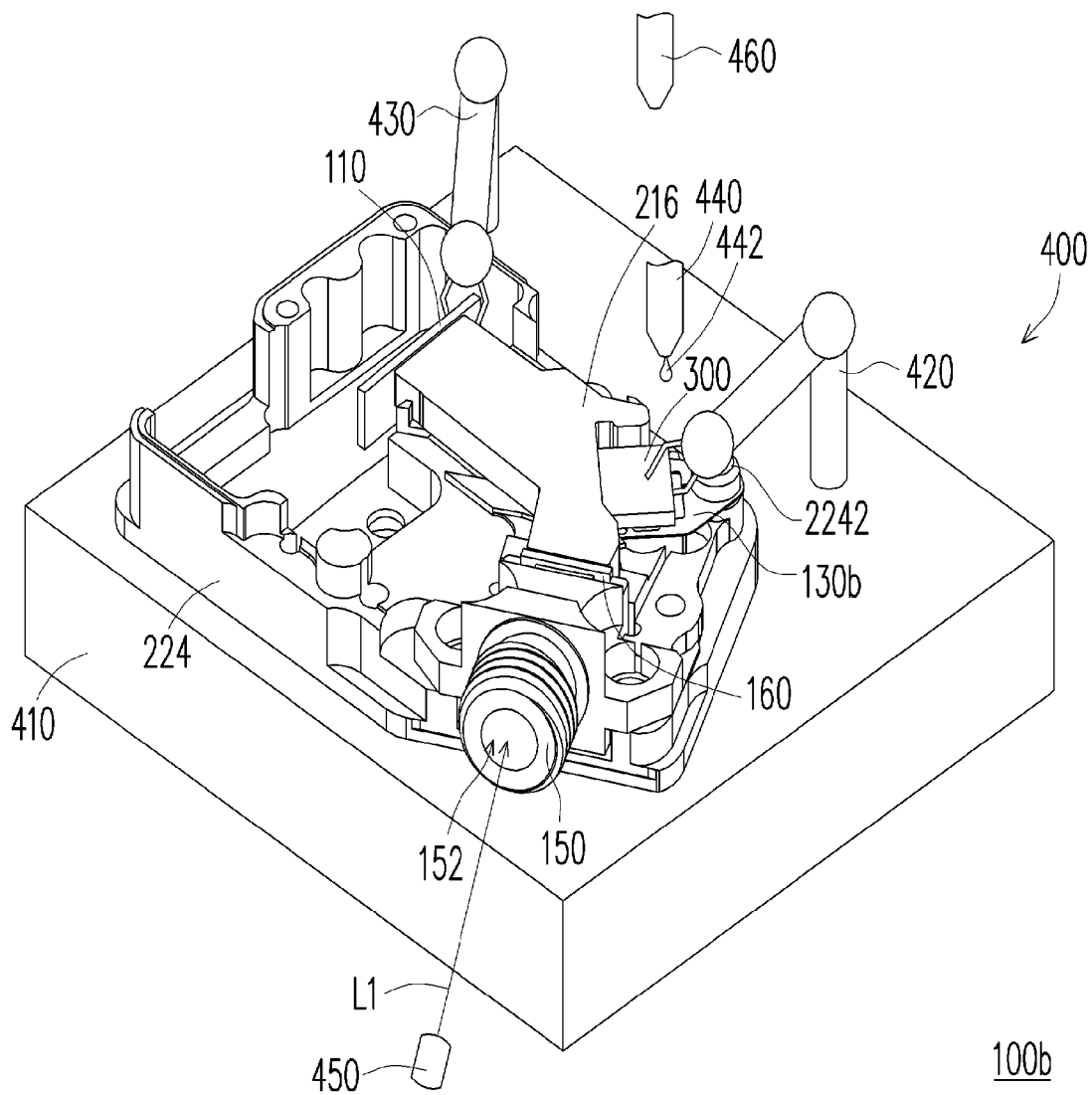


FIGURE 13D

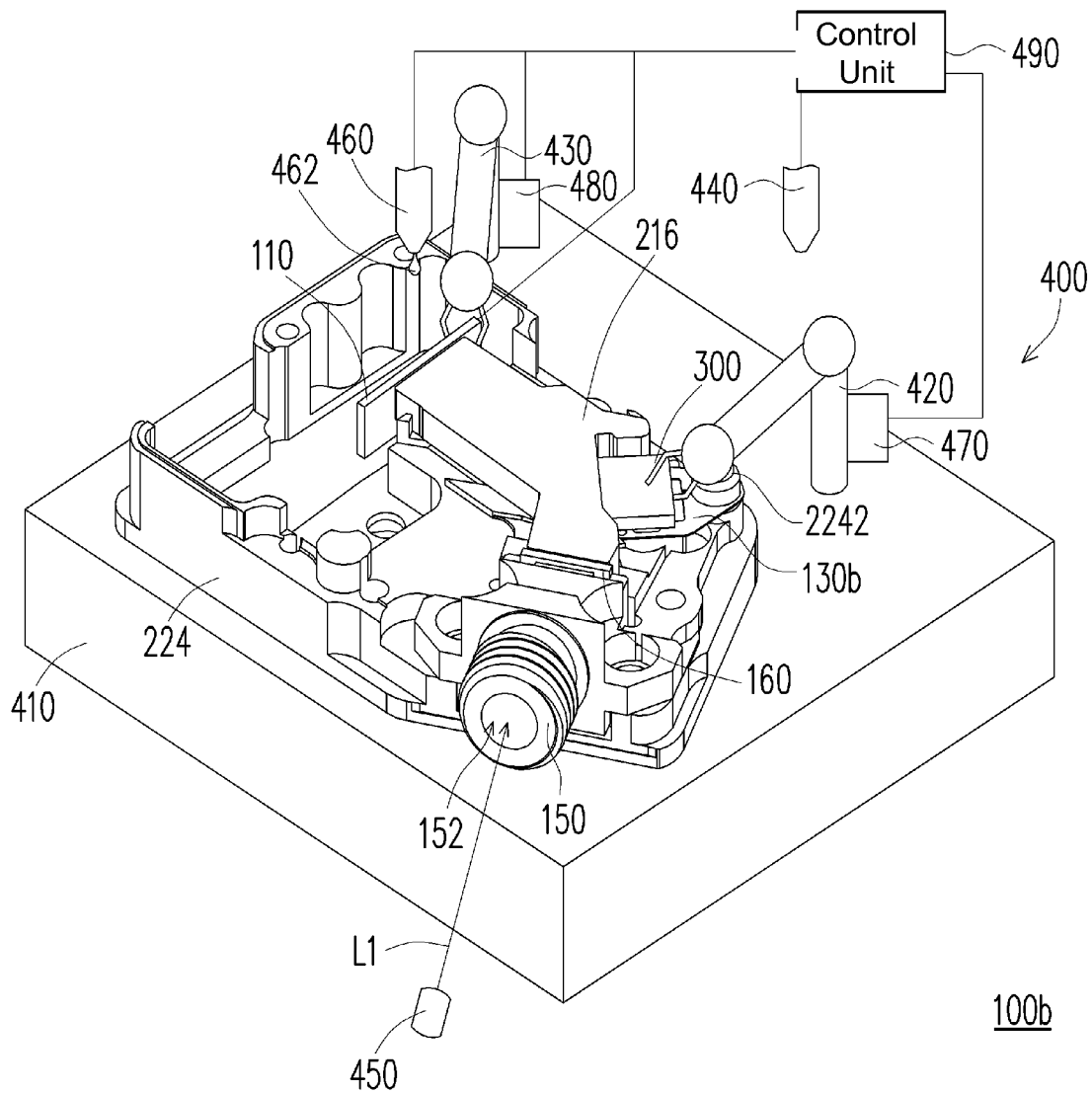


FIGURE 13E

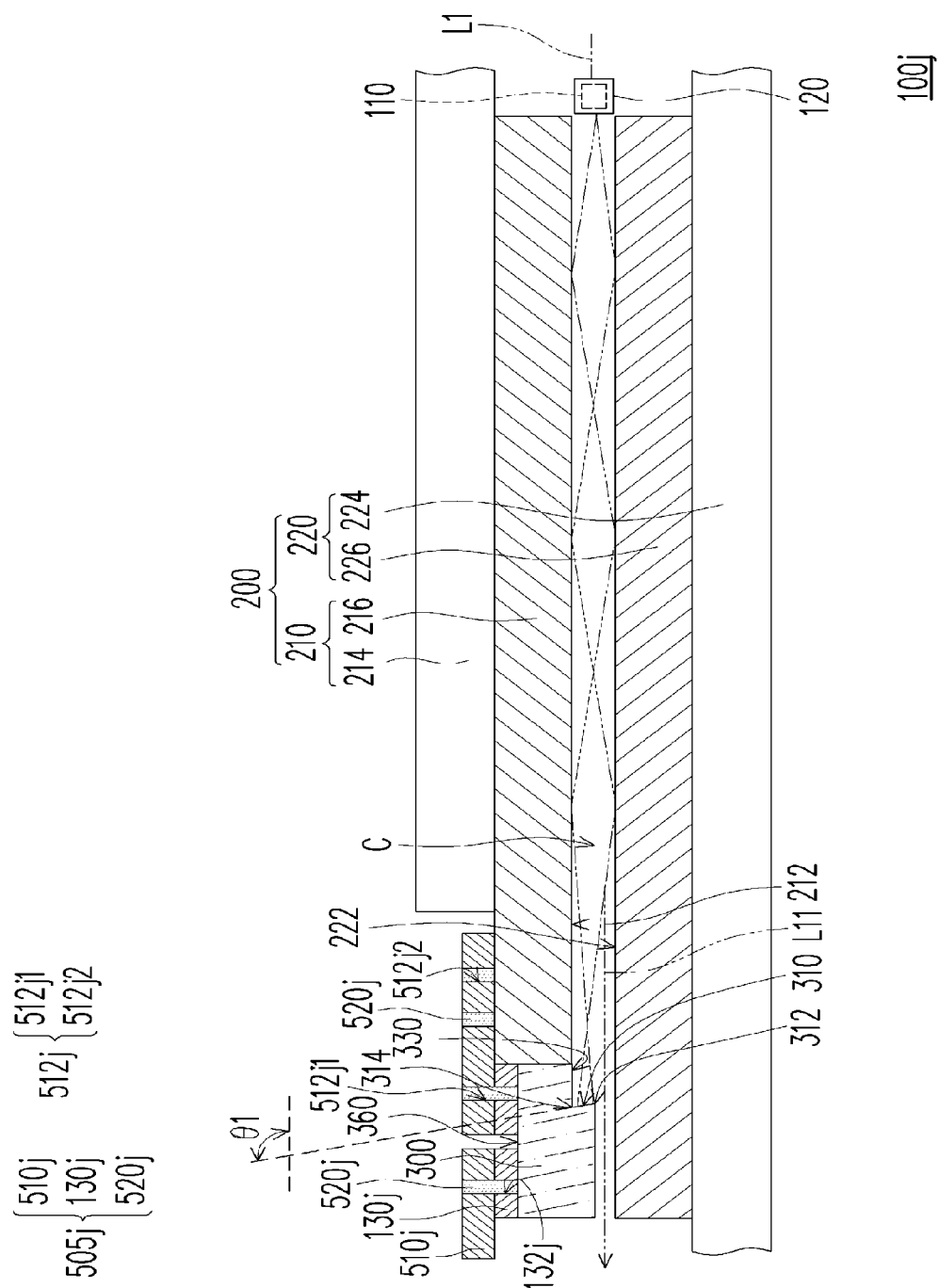


FIGURE 14A

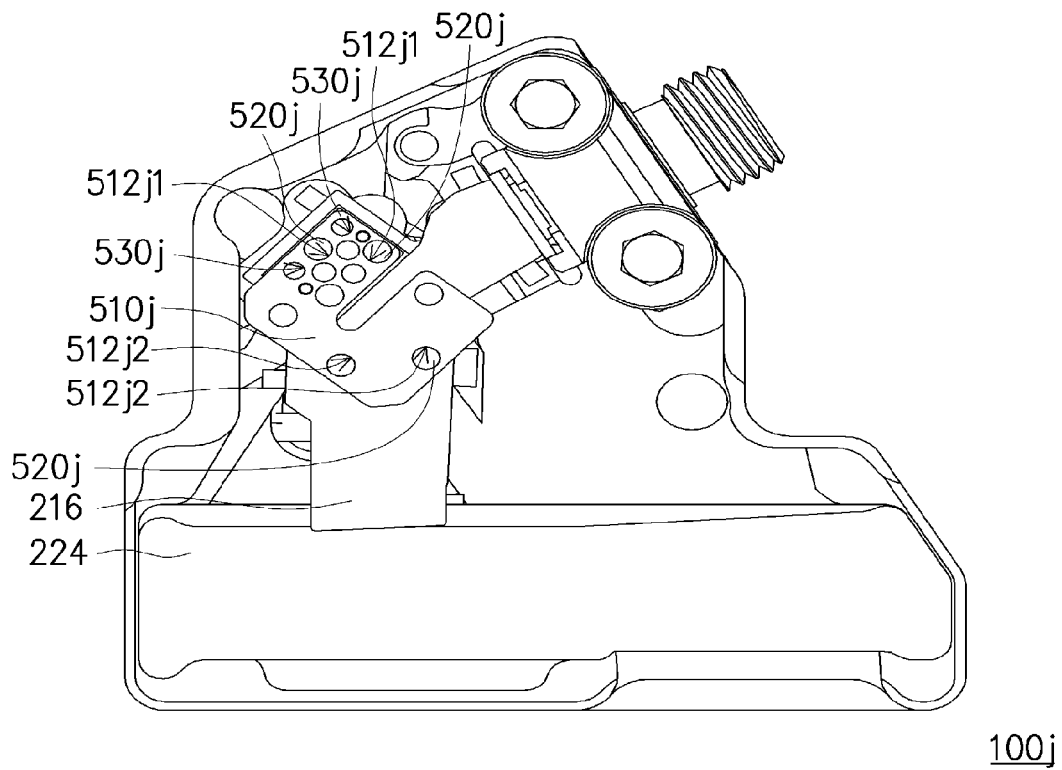


FIGURE 14B

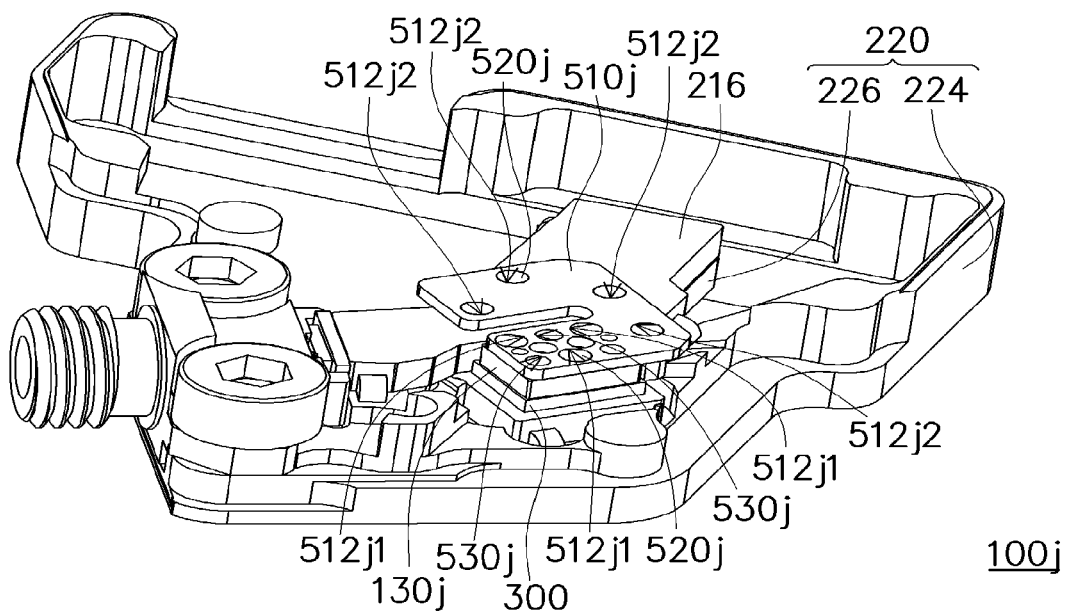


FIGURE 14C

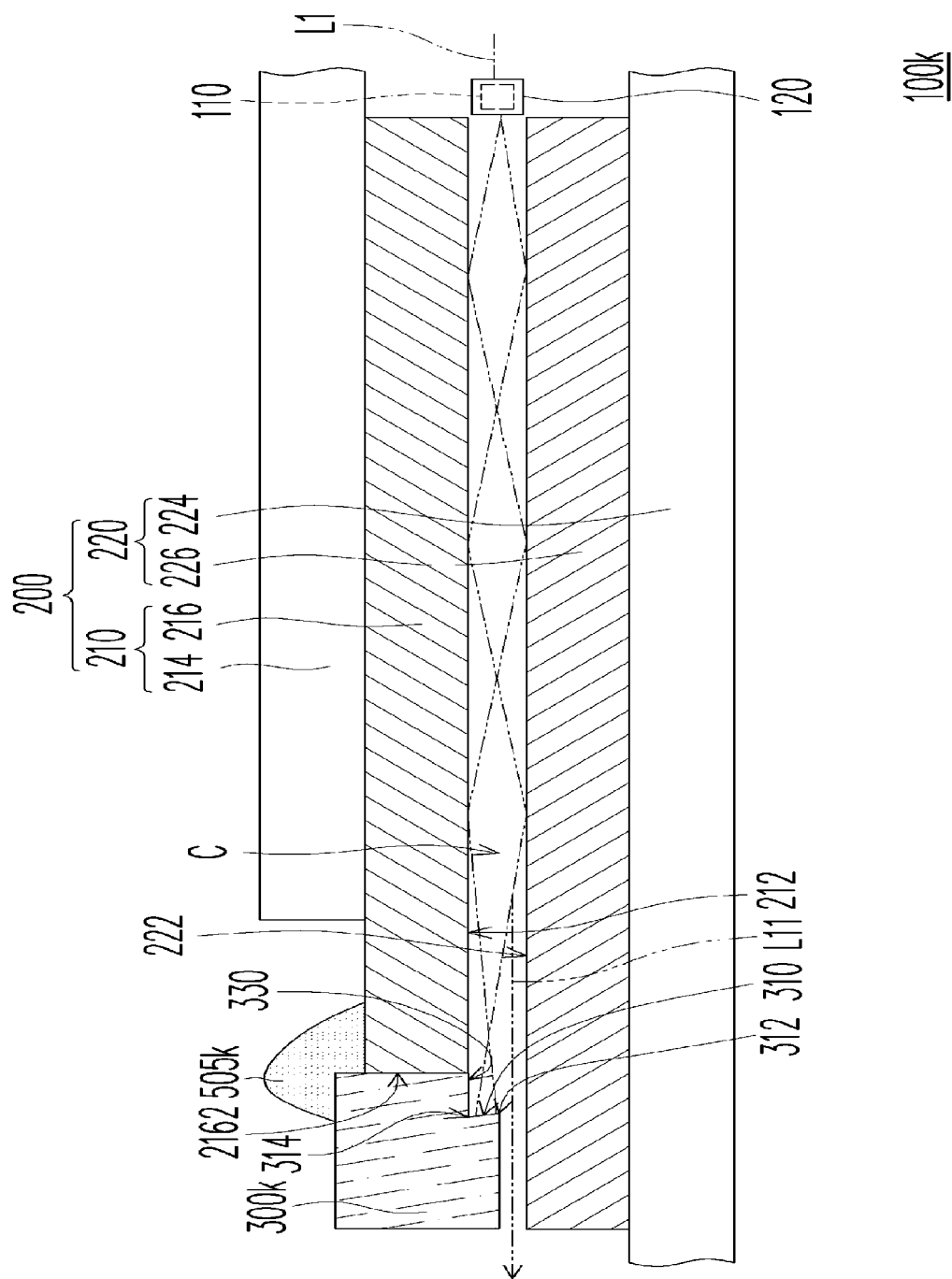


FIGURE 15

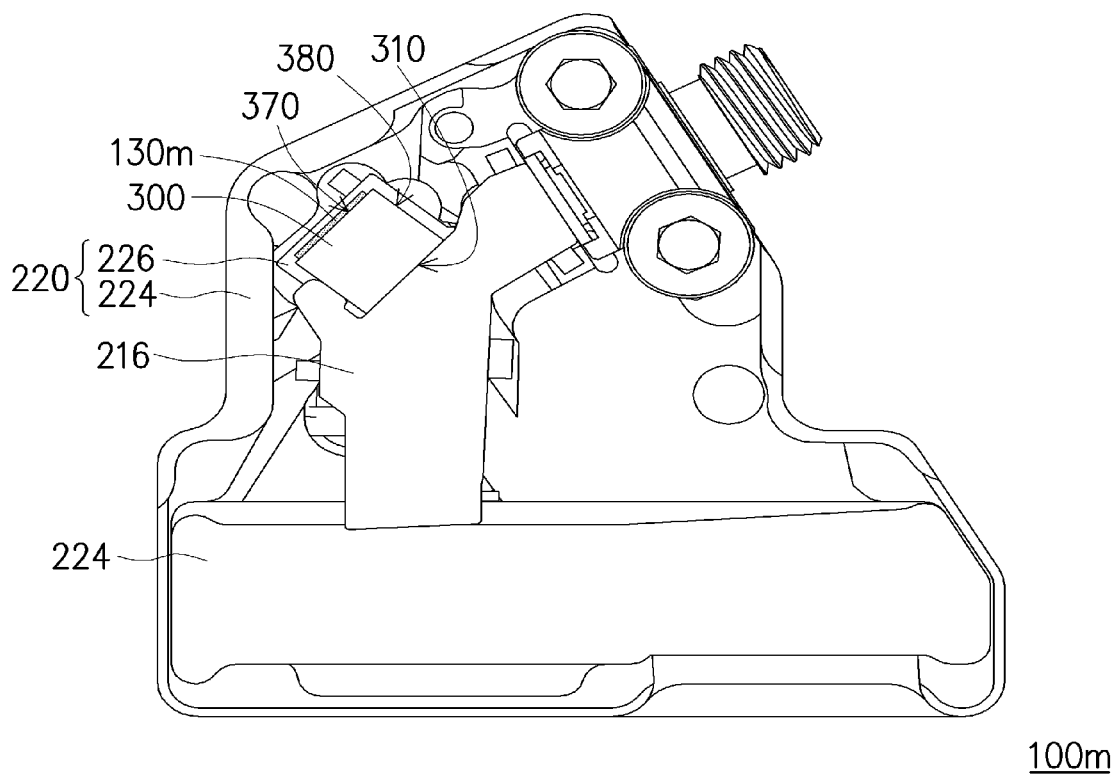


FIGURE 16

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SPECTROMETER, ASSEMBLING METHOD THEREOF, AND ASSEMBLING SYSTEM

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the priority benefit of Taiwan Patent Application No. 101142874, filed on Nov. 16, 2012, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present invention relates to a light instrument, associated assembling method and assembling system, and more particularly relates to a spectrometer, its associated assembling method and assembling system.

BACKGROUND

A spectrometer can typically disperse light of complex composition into a light spectrum, and may include a prism or a diffractive grating. Spectrometers can measure how much light is reflected from or transmitted through an object. Optical signals captured by a spectrometer can be developed on photographic films or be displayed and analyzed by a computer to give information on elemental compositions of the object to be measured. Based on optical principles, spectrometers are often used to observe, analyze, and process the structure and composition of matters. There are several advantages associated with spectrometers, including: high precision and accuracy, large measurement range, high speed and smaller amount of sample used, etc. Therefore, spectrometers have been widely used by agencies and institutes in the areas of metallurgy, geology, petroleum and chemical industries, medicine and health, and environmental protection. In addition, spectrometers are also a necessity for applications in military reconnaissance, space exploration, and resources and hydrological surveys.

SUMMARY

The present invention provides a spectrometer which can improve the optical quality of spectra measured by the spectrometer.

The present invention also provides a method for assembling a spectrometer which can improve the optical quality of spectra measured by the spectrometer.

The present invention further provides a system, for assembling a spectrometer, through which relative positions of a diffractive component and a light sensor can be precisely adjusted.

According to one aspect, a spectrometer may comprise a waveguide module, a diffractive component, and a light sensor. The waveguide module may include a first reflective surface, a second reflective opposite to the first reflective surface, and a light channel located between the first reflective surface and the second reflective surface. The diffractive component may include a diffractive surface with a plurality of strip-shaped diffractive structures. A sharpness of a profile of the strip-shaped diffractive structures at a first side of the diffractive surface may be greater than a sharpness of the profile of the strip-shaped diffractive structures at a second side of the diffractive surface. The first side of the diffractive surface may be located between the first reflective surface and the second reflective surface, with the first side of the diffractive surface spaced apart from the second reflective surface, when viewed along a direction generally perpendicular to the

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second reflective surface. The light sensor may receive diffracted light after light transmitted in the light channel is diffracted into the diffracted light by the diffractive surface.

In at least one embodiment, the waveguide module may comprise a first base body and a second base body. The first base body may include the first reflective surface. The second base body may include the second reflective surface. The light channel may be formed between the first base body and the second base body. The diffractive component may be disposed on at least one of the first base body or the second base body.

In at least one embodiment, the spectrometer may further comprise a heightening component disposed between the diffractive component and at least one of the first base body or the second base body.

In at least one embodiment, the spectrometer may further comprise a light input port. At least a part of light entering into the spectrometer via the light input port may be transmitted within the light channel to the diffractive surface of the diffractive component.

In at least one embodiment, a light output channel may be formed between the diffractive component and the second base body. The light output channel may be adjacent to the heightening component. A part of the light entering into spectrometer via the light input port may exit the light channel via the light output channel.

In at least one embodiment, the heightening component and the diffractive components may be formed integrally.

In at least one embodiment, the heightening component may comprise a plurality of spacers spaced apart with respect to each other in a direction substantially parallel to the second reflective surface.

In at least one embodiment, the heightening component may include a light absorbing surface.

In at least one embodiment, the heightening component may comprise a transparent component.

In at least one embodiment, the heightening component may comprise at least one light confinement groove, located on a surface of the heightening component facing the light channel, such that light entering into the at least one confinement groove is repeatedly reflected by and confined in the at least one light confinement groove.

In at least one embodiment, the heightening component may comprise at least one position reference mark that indicates relative positions of the diffractive component and the heightening component.

In at least one embodiment, the second base body may comprise a case and a reflective plate disposed on the case. A surface of the reflective plate may be the second reflective surface, and the heightening component may be disposed on the reflective plate.

In at least one embodiment, the second base body may comprise a case and a reflective plate disposed on the case. A surface of the reflective plate may be the second reflective surface, and the heightening component may be disposed on the case.

In at least one embodiment, the waveguide module may comprise a first base body, having the first reflective surface, a second base body, having the second reflective surface, and an adhesive material. The light channel may be formed between the first base body and the second base body. The adhesive material may secure the diffractive component to at least one of the first base body or the second base body.

In at least one embodiment, the diffractive component may include a backside opposite to the diffractive surface. The adhesive material may connect the backside of the diffractive

component to the second base body such that the diffractive component is secured on the second base body.

In at least one embodiment, the waveguide module may comprise a first base body, having the first reflective surface, and a second base body, having the second reflective surface. The light channel may be formed between the first base body and the second base body. At least one of the first base body or the second base body may include a fixing component that secures a position of the diffractive component.

In at least one embodiment, the waveguide module may comprise a light guiding body provided as the light channel, a first reflective film disposed on the light guiding body, and a second reflective film disposed on the light guiding body such that the light guiding body is between the first reflective film and the second reflective film. An interface between the first reflective film and the light guiding may form the first reflective surface. An interface between the second reflective film and the light guiding body may form the second reflective surface.

In at least one embodiment, the diffractive component may comprise a notch having a bottom surface and the diffractive surface. The diffractive surface may be inclined relative to the bottom surface. The bottom surface may be inclined relative to the second reflective surface such that the diffractive surface is approximately parallel with a normal vector of the second reflective surface.

In at least one embodiment, the strip-shaped diffractive structures may be substantially parallel with respect to each other. The diffractive surface may be a curved concave surface.

In at least one embodiment, the diffractive component may comprise a notch and a surface. The notch may include a respective diffractive surface and a bottom surface connected to the respective diffractive surface. The surface may be connected to the bottom surface. At least a portion of the surface may face the light channel and may be coated with a light absorbing material.

In at least one embodiment, the diffractive surface may be formed by etching started from the first side of the diffractive surface.

In at least one embodiment, the spectrometer may further comprise a positioning means for setting a position of the first side of the diffractive surface such that the first side of the diffractive surface is spaced apart from the second reflective surface when viewed from a direction perpendicular to the second reflective surface.

In at least one embodiment, the diffractive component may comprise a notch and an allocation surface. The notch may include a respective diffractive surface and a bottom surface connected to the respective diffractive surface. The allocation surface may be connected to the bottom surface of the notch. The allocation surface may face the second reflective surface and may be coated with a reflective material.

In at least one embodiment, the waveguide module may comprise a first base body, having the first reflective surface, and a second base body, having the second reflective surface. The light channel may be formed between the first base body and the second base body. The spectrometer may further comprise a connecting unit that connects the diffractive component to the first base body of the waveguide module. A deformation of the first base body due to a temperature change in the spectrometer may cause a change in a dimension of the diffractive component.

In at least one embodiment, the connecting unit may comprise a fixing component and a plurality of pieces of an adhesive material. The fixing component may be disposed on the first base body. The fixing component may include a

plurality of first through holes. A first part of the first through holes may expose a portion of the diffractive component, and a second part of the first through holes may expose a portion of the first base body. The plurality of pieces of an adhesive material may be filled in the first through holes. Some of the pieces of the adhesive material filled in the first part of the first through holes may connect the fixing component to the diffractive component. Some other pieces of the adhesive material filled in the second part of the first through holes may connect the fixing component to the first base body.

In at least one embodiment, the connecting unit may comprise a gasket disposed between the diffractive component and the fixing component. The gasket may include at least one second through hole interlinked with the first part of the first through holes such that the first part of the first through holes and the at least one second through hole are filled with the adhesive material to connect the fixing component, the gasket, and the diffractive component together.

In at least one embodiment, the first base body may comprise a reflective plate and a case. The reflective plate may be disposed on the second base body and may include the first reflective surface. The connecting unit may connect the diffractive component and the reflective plate. A deformation of the reflective plate due to a temperature change in the spectrometer may cause a change in a dimension of the diffractive component through the connecting unit. The case may cover the reflective plate.

In at least one embodiment, the reflective plate may include a side to which the diffractive component is secured by the connecting unit. The connecting unit may comprise an adhesive material.

According to another aspect, a spectrometer may comprise a waveguide module, a diffractive component, and a light sensor. The waveguide module may include a first reflective surface, a second reflective surface opposite to the first reflective surface, and a light channel located between the first reflective surface and the second reflective surface. The diffractive component may include an allocation surface and a notch located on a side of the allocation surface. The notch may include a diffractive surface that is inclined relative to the second reflective surface such that the diffractive surface is generally parallel with a normal vector of the second reflective surface. The light sensor may receive diffracted light after light transmitted in the light channel is diffracted into the diffracted light by the diffractive surface.

In at least one embodiment, the waveguide module may comprise a first base body, having the first reflective surface, and a second base body, having the second reflective surface. The light channel may be formed between the first base body and the second base body. The diffractive component may be disposed on at least one of the first base body or the second base body.

In at least one embodiment, the spectrometer may further comprise a heightening component disposed between the diffractive component and the second base body and disposed on a side of the diffractive component away from the diffractive surface.

According to one aspect, a method for assembling a spectrometer may comprise: disposing a diffractive component along a side of a light channel of a waveguide module, wherein the waveguide module comprises a first reflective surface and a second reflective surface opposite to the first reflective surface, wherein the light channel is located between the first reflective surface and the second reflective surface, and wherein the diffractive component has a diffractive surface; disposing a light sensor on one end of the light channel; transmitting light to the diffractive surface via the

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light channel such that at least a portion of the light is diffracted into diffracted light by the diffractive surface and the diffracted light is incident on the light sensor; adjusting at least one of a position of the diffractive surface along a direction substantially perpendicular to the second reflective surface or an angle between the diffractive surface and the second reflective surface, and measuring a corresponding spectrum of light incident on the light sensor; determining whether the spectrum of the light incident on the light sensor meets a predefined first sharpness condition; and securing the diffractive component when the spectrum of the light incident on the light sensor meets the predefined first sharpness condition; or adjusting either or both of the position and the angle of the diffractive surface until the spectrum of the light incident on the light sensor meets the predefined first sharpness condition.

In at least one embodiment, transmitting light to the diffractive surface may comprise transmitting the light to the diffractive surface sequentially through a light input port and the light channel. The method may further comprise adjusting the position of the diffractive surface along a direction that is substantially parallel to the second reflective surface and substantially perpendicular to a line connecting the light input port and the diffractive surface.

In at least one embodiment, transmitting light to the diffractive surface may comprise transmitting the light to the diffractive surface sequentially through a light input port and the light channel. The method may further comprise adjusting a distance between the diffractive surface and the light input port.

In at least one embodiment, the method may further comprise adjusting a first rotation angle of the diffractive surface. The first rotation angle may be an angle around an axis that is substantially parallel to a normal vector of the second reflective surface.

In at least one embodiment, transmitting light to the diffractive surface may comprise transmitting the light to the diffractive surface sequentially through a light input port and the light channel. The method may further comprise adjusting a second rotation angle of the diffractive surface. The second rotation angle may be an angle around an axis that is substantially parallel to a line connecting the light input port and the diffractive surface.

In at least one embodiment, securing the diffractive component may comprise securing the diffractive component to at least one of the first or the second base bodies by an adhesive material. The first base body may include the first reflective surface, and the second base body may include the second reflective surface.

In at least one embodiment, the method may further comprise adjusting at least one of a position or an angle of the light sensor with respect to the light channel.

In at least one embodiment, the method may further comprise: adjusting at least one of a position or an angle of the light sensor with respect to the light channel after securing the diffractive component, and measuring a corresponding spectrum of the light incident on the light sensor; determining whether the corresponding spectrum of the light incident on the light sensor meets a predefined second sharpness condition; and securing the light sensor when the corresponding spectrum of the light incident on the light sensor meets the predefined second sharpness condition; or adjusting at least one of the position or the angle of the light sensor until the corresponding spectrum of the light incident on the light sensor meets the predefined second sharpness condition.

In at least one embodiment, adjusting at least one of a position of the diffractive surface in a direction substantially

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perpendicular to the second reflective surface or an angle between the diffractive surface and the second reflective surface may comprise determining at least one of the position or the angle of the diffractive surface in a second measurement based on the at least one of the position or the angle of the diffractive surface used to obtain a spectrum in a first measurement.

According to one aspect, an assembling system may comprise: a carrier that carries a waveguide module, the waveguide module having a first reflective surface, a second reflective surface opposite to the first reflective surface, and a light channel located between the first reflective surface and the second reflective surface; a first fixture that carries a diffractive component having a diffractive surface disposed along a side of the light channel, the first fixture configured to adjust at least one of a position of the diffractive component along a direction substantially perpendicular to the second reflective surface or an angle between the diffractive surface and the second reflective surface; and a second fixture that carries a light sensor disposed at one end of the light channel, the second fixture configured to adjust at least one of a position or an angle of the light sensor.

In at least one embodiment, one end of the waveguide module may include a light input port. The first fixture may adjust a position of the diffractive surface along a direction that is substantially parallel to the second reflective surface and substantially perpendicular to a line connecting the light input port and the diffractive surface.

In at least one embodiment, one end of the waveguide module may include a light input port. The first fixture may adjust a distance between the diffractive surface and the light input port.

In at least one embodiment, the first fixture may adjust a first rotation angle of the diffractive surface. The first rotation angle may be an angle around an axis that is substantially parallel to a normal vector of the second reflective surface.

In at least one embodiment, one end of the waveguide module may include a light input port. The first fixture may adjust a second rotation angle of the diffractive surface. The second rotation angle may be an angle around an axis that is substantially parallel to a line connecting the light input port and the diffractive surface.

In at least one embodiment, the assembling system may further comprise an adhesive dispenser. The adhesive dispenser may apply an adhesive material onto the diffractive component to secure the diffractive component to at least one of a first base body having the first reflective surface or a second base body having the second reflective surface.

In at least one embodiment, the assembling system may further comprise a first actuator that drives the first fixture, a second actuator that drives the second fixture, and a control unit electrically connected to the first actuator and the second actuator to control operations of the first actuator and the second actuator.

In at least one embodiment, the control unit may be electrically connected to the light sensor and the adhesive dispenser. The control unit may receive spectral signals measured by the light sensor and determining at least one of a position or an angle of the diffractive component and at least one of a position or an angle of the light sensor based on the received spectral signals. The control unit may determine whether a sharpness of the spectral signals meets a standard based on a determination procedure such that, when the standard are met. The control unit may command the adhesive dispenser to apply the adhesive material onto the diffractive component, otherwise, the control unit may command the first actuator and the second actuator to adjust the at least one

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of the position or the angle of the diffractive component or the at least one of the position or the angle of the light sensor until the sharpness of the spectral signals meets the standard. As to the spectrometer in accordance with the embodiments of the present invention, when viewed along a direction perpendicular to the second reflective surface, the first side of the diffractive surface is positioned between the first reflective surface and the second reflective surface with a distance away from the second reflective surface, a portion of light transmitted in the light channel with higher intensity is diffracted by the part of the diffractive surface having a sharper profile. As a result, the optical quality of the spectra measured by the spectrometer can be enhanced. As to the spectrometer in accordance with the embodiments of the present invention, since the allocation surface of the diffractive component is inclined relative to the second reflective surface, the diffractive surface is generally parallel with the normal vector of the second reflective surface. As a result, the optical quality of the spectra obtained can be enhanced. As to the method for assembling spectrometers in accordance with the embodiments of the present invention, since the diffractive component is secured after at least one of the position and angle of the diffractive component has been adjusted until the spectrum obtained meets the predefined sharpness condition, the diffractive component can be secured at an appropriate position. As a result, the optical quality of the spectra obtained can be enhanced. As to the system for assembling the spectrometer in accordance with the embodiments of the present invention, since the first fixture and the second fixture are configured to adjust the diffractive component and the light sensor, respectively, the relative positions of the diffractive component and the light sensor can be accurately adjusted. As a result, the optical quality of the spectra obtained can be enhanced.

Detailed description of selected embodiments of the present invention is provided below with reference to the attached figures to aid better understanding of the present invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1A is a side view of a spectrometer in accordance with one embodiment of the present invention.

FIG. 1B is a top view of the spectrometer of FIG. 1A.

FIG. 1C is a perspective view of a diffractive grating and a heightening component of the spectrometer of FIG. 1A.

FIG. 2 is a graph showing distribution of light intensity on a plane located at a junction of a diffractive component and a light channel.

FIG. 3A is a diagram of a bulk semiconductor used to make the diffractive component.

FIG. 3B is a diagram showing the bulk semiconductor of FIG. 3A being etched to form a heightening component.

FIG. 4 is a side view of a spectrometer in accordance with another embodiment of the present invention.

FIG. 5A is a perspective view of a spectrometer in accordance with yet another embodiment of the present invention.

FIG. 5B is an exploded perspective view of the spectrometer of FIG. 5A.

FIG. 5C is a perspective view of a heightening component of the spectrometer of FIG. 5A.

FIG. 6 is diagram of a variation of the heightening component of FIG. 5C.

FIG. 7 is a perspective view of a diffractive component and a heightening component in accordance with another embodiment of the present invention.

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FIG. 8 is a side view of a spectrometer in accordance with still another embodiment of the present invention.

FIG. 9 is a partial side view of a spectrometer in accordance with another embodiment of the present invention.

FIG. 10 is a side view of a spectrometer in accordance with yet another embodiment of the present invention.

FIG. 11 is a side view of a spectrometer in accordance with still another embodiment of the present invention.

FIG. 12 is a side view of a spectrometer in accordance with another embodiment of the present invention.

FIGS. 13A to 13E are diagrams illustrating an assembling system in accordance with one embodiment of the present invention to explain the associated assembling procedure.

FIG. 14A is a side view of a spectrometer in accordance with a further embodiment of the present invention.

FIG. 14B is a top view of the spectrometer of FIG. 14A after a case 214 is removed.

FIG. 14C is a perspective view of the spectrometer of FIG. 14A after the case 214 is removed.

FIG. 15 is a side view of a spectrometer in accordance with another embodiment of the present invention.

FIG. 16 is a top view of a spectrometer with a case partially removed in accordance with yet another embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1A is a side view of a spectrometer in accordance with one embodiment of the present invention. FIG. 1B is a top view of the spectrometer of FIG. 1A. In order to aid readers in understanding the relative positions of the light input port, the diffractive component, and the light sensor, the first base body and the second base body in FIG. 1A are omitted in FIG. 1B. FIG. 1C is a perspective view of a diffractive grating and a heightening component of the spectrometer of FIG. 1A. Referring to FIGS. 1A, 1B and 1C, a spectrometer 100 of the present embodiment includes a waveguide module 200, a diffractive component 300, and a light sensor 110. In the present embodiment, the spectrometer 100 includes a light input port 120 through which light L1, to be measured, enters into the spectrometer 100. FIG. 1A is a side view of FIG. 1B, as viewed from the light input port 120 towards the light sensor 110; therefore, in FIG. 1A, the light sensor 110 is located behind the light input port 120.

The waveguide module 200 includes a first reflective surface 212, a second reflective surface 222 opposite to the first reflective surface 212, and a light channel C located between the first reflective surface 212 and the second reflective surface 222. The diffractive component 300 has a diffractive surface 310 with a plurality of strip-shaped diffractive structures 320 thereon. The sharpness of the profile of the strip-shaped diffractive structures 320 on a first side 312 of the diffractive surface 320 is greater than that of the strip-shaped diffractive structures 320 on a second side 314 of the diffractive surface 320. In the present embodiment, the diffractive component 300 includes an allocation surface 350 with a notch 305 provided on one side of the allocation surface 350. The notch 305 has a bottom surface 330 and a diffractive surface 310 connected to the bottom surface 330. In addition, in the present embodiment, the diffractive component 300 is made of a semiconductor material, such as silicon for example but not limited thereto. The notch 305 is formed, for example, by a semiconductor etching process. A bulk semiconductor material is etched, along a direction from the first side 312 towards the second side 314 through a photomask or a mask with the diffractive structure profile, until the bottom

surface 330 is reached. The strip-shaped diffractive structures 320 are also formed during this etching process. The semiconductor etching process is, for example, the etching process used in fabricating micro-electro-mechanical systems (MEMS). Since the etching is along a direction from the first side 312 towards the second side 314, the sharpness of the profile of the strip-shaped diffractive structures 320 in the present embodiment decreases along the direction from the first side 312 towards second side 314.

The diffractive surface 310 diffracts light L1, transmitted in the light channel C, and the diffracted light is transmitted to the light sensor 110. In the present embodiment, the light sensor 110 is an image sensor, such as a one-dimensional image sensor for example. However, in other embodiments, the light sensor 110 may be a two-dimensional image sensor. The light input port 120 is, for example, a slit, which may extend in a direction substantially parallel to the extending direction of the stripe-shaped diffractive structures 320. At least a portion of the light L1 that enters into the spectrometer 100 via the light input port 120 is transmitted in the light channel C to the diffractive surface 310 of the diffractive component 300. More specifically, at least a portion of the light L1 that enters into the light channel C via the light input port 120 is continuously reflected by the first reflective surface 212 and the second reflective surface 222, and then transmitted to the diffractive surface 310. The diffractive surface 310 diffracts light L1, forming diffracted light of numerous different orders, LC0, LC1, LC2, LC3, LC4. At least a portion of the diffracted light LC0, LC1, LC2, LC3, LC4 is transmitted to the light sensor 110 where a spectrum is formed.

FIG. 2 is graph showing distribution of light intensity on a plane located at a junction of the diffractive component 300 and the light channel C. In FIG. 2, a direction from the first reflective surface 212 to the second reflective surface 222 is represented by the vertical direction, while a direction from a first end E1 on the diffractive surface 310 which is away from the light input port 120 to a second end E2 on the diffractive surface 310 which is closer to the light input port 120 is represented by the horizontal direction. As shown in FIG. 2, in the present embodiment, since the intensity of the light L1 entering through the light input 120 has, for example, a Gaussian distribution, and the light L1 is continuously reflected by the first reflective surface 212 and the second reflective surface 222, the maximum intensity of the light L1 is located approximately on a midplane between the first reflective surface 212 and the second reflective surface 222. The distance between the midplane and the first reflective surface 212 is substantially equal to the distance between the midplane and the second reflective surface 222. In addition, since the first end E1 is further away from the light input port 120 compared to the second end E2, in the horizontal direction, the intensity of the light L1 tends to gradually increase along a direction from the first end E1 towards the second end E2.

In the present embodiment, when viewed along a direction perpendicular to the second reflective surface 222, the first side 312 of the diffractive surface 310 is located between the first reflective surface 212 and the second reflective surface 222 with a spacing, or gap, T between the first side 312 of the diffractive surface 310 and the second reflective surface 222. That is, when viewed from either the top or the bottom of FIG. 1A, the first side 312 is located between the first reflective surface 212 and the second reflective surface 222 with the spacing T between the first side 312 and the second reflective surface 222. Due to the greater sharpness of the profile of the strip-shaped diffractive structures 320 on the first side 312 of the diffractive surface 310 and the resulting better diffraction

effect, and due to the lower intensity of the light L1 in the vicinity of the first reflective surface 212 and the second reflective surface 222 as well as the higher intensity of the light L1 in the vicinity of the midplane between the first reflective surface 212 and the second reflective surface 222, a height position of the first side 312 (i.e., the position in a direction perpendicular to the second reflective surface 222) is located between the first reflective surface 212 and the second reflective surface 222. This allows the portion of the light L1 with higher intensity to be diffracted by the portion of the stripe-shaped diffractive structures 320 with sharper profile, thereby enhancing the optical quality (e.g., the resolution and/or sensitivity) of the spectra measured by the light sensor 110. Furthermore, in FIG. 1C, when a surface 340 faces the optical channel C, light L1 will be incident on the surface 340 to produce stray light. However, in FIG. 1A, the presence of the heightening component 130 causes the position of the surface 340 to shift to a side facing a reflective plate 216, thus effectively reducing the formation of stray light.

In the present embodiment, the waveguide module 200 includes a first base body 210, which has the first reflective surface 212, and a second base body 220, which has the second reflective surface 222. The light channel C is formed between the first base body 210 and the second base body 220, and the diffractive component 300 is disposed on the second base body 220. In the present embodiment, the first base body 210 includes a case 214 and the reflective plate 216, which is disposed on the case 214. The first reflective surface 212 serves as the surface of the reflective plate 216. Similarly, the second base body 220 may also include a case 224 and a reflective plate 226, which is disposed on the case 224. The second reflective surface 222 serves as the surface of the reflective plate 226. In addition, the reflective plate 216 is disposed between the reflective plate 226 and the case 214, and the reflective plate 226 is disposed between the reflective plate 216 and the case 224. In the present embodiment, the light channel C is the space formed between the reflective plate 216 and the reflective plate 226 such that a waveguide is formed between the reflective plate 216 and the reflective plate 226.

In the present embodiment, the spectrometer 100 also includes a positioning means so as to position the first side 312 of the diffractive surface 310 between the first reflective surface 212 and the second reflective surface 222 and to keep the spacing T between the first side 312 of the diffractive surface 310 and the second reflective surfaces 222, when viewed along a direction perpendicular to the second reflective surface 222. In the present embodiment, the positioning means may be the heightening component 130, disposed between the diffractive component 300 and the second base body 220. In the present embodiment, the heightening component 130 is disposed on the reflective plate 226, and the diffractive component 300 is disposed on the heightening component 130. However, in other embodiments, the heightening component 130 may also be disposed on the case 224, and the diffractive component 300 may be disposed on the heightening component 130. In the present embodiment, the heightening component 130 is, for example, a gasket. In the present embodiment, the heightening components 130 can increase the height of the allocation surface 350 so as to change the position of the diffractive surface 310, thereby positioning the first side 312 of the diffractive surface 310 closer to the midplane between the first reflective surface 212 and the second reflective surface 222. Due to the higher intensity of light on the midplane, positioning the first side 312 (where the sharpness of the profile of the stripe-shaped diffractive structures 320 is greater) closer to the midplane

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can enhance the diffraction effect of the diffractive surface 310. In other embodiments, the heightening component 130 may also be integrally formed with the diffractive component 300. For example, both the heightening component 130 and the diffractive components 300 can be made of the same semiconductor material (such as silicon). Before using the semiconductor etching process to form the notch 305, a bulk semiconductor material 50 (as shown in FIG. 3A) can be etched to form the heightening component 130 first as shown in FIG. 3B. Subsequently, the remaining portion 60 of the bulk semiconductor material 50 can be further etched to form the notch 305 and the diffractive surface 310 as shown in FIG. 1C.

In the present embodiment, a light output channel A adjacent to the heightening component 130 is formed between the diffractive component 300 and the second base body 220, through which another portion of the light L11 coming from the light input port 120 exits the light channel C. In the present embodiment, the heightening components 130 may be in the form of a triangle, and a space (i.e., the light output channel A) next to the hypotenuse of the triangle can be provided to allow the light L11 to pass through. In this way, the light L11 can exit the light channel C via the light output channel A rather than being reflected by the heightening component 130 to generate stray light inside the light channel C to thereby impact the quality of the spectra measured by the light sensor 110. This design advantageously reduces the noise level of the spectra. In the present embodiment, the heightening component 130 includes a surface 133 that can be, for example, a light absorbing surface that absorbs the part of the light L1 that is incident on the heightening component 130. As a result, no stray light would be derived from this part of the light L1 to affect the quality of the spectra. However, in other embodiments, the heightening component 130 may also be a transparent component, so that the part of the light L1 incident on the heightening component 130 can directly pass through the heightening component 130 and exit the light channel C without forming stray light in the light channel C to affect the quality of the spectra. In other embodiments, the heightening component 130 may also be in a non-triangular form to provide the light output channel A. Rather, the heightening component 130 may have a shape generally corresponding to the shape of the diffractive component 300 (e.g., in a rectangular form) with no light output channel A formed. In addition, the heightening component 130, which has a shape generally corresponding to the shape of the diffractive component 300, may have a light absorbing surface, or the heightening component 130 may also be transparent so as to reduce the formation of stray light.

In the present embodiment, the strip-shaped diffractive structures 320 are positioned substantially parallel with respect to each other, and the diffractive surface 310 is a curved concave surface. In other words, these strip-shaped diffractive structures 320 are arranged substantially parallel with respect to each other on a curved surface. In this way, light L1 diffracted by the diffractive surface 310, which is curved, can be transmitted in a converging manner to the light sensor 110. Accordingly, between the diffractive surface 310 and the light sensor 110, either no lens for the purpose of focusing the diffracted light L1 is needed or fewer lenses would be needed to focus the diffracted light L1. As a result, the volume or size of the spectrometer 100 can be effectively reduced.

FIG. 4 is a side view of a spectrometer in accordance with another embodiment of the present invention. Referring to FIG. 4, the spectrometer 100a of the present embodiment is similar to the spectrometer 100 shown in FIG. 1A. Differ-

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ences between the spectrometer 100a and the spectrometer 100 are described below. The thickness of the heightening component 130a in the spectrometer 100a of the present embodiment is less than the thickness of the heightening component 130 shown in FIG. 1A; therefore, at least a part of the surface 340 of the diffractive component 330 that is connected to the bottom surface 330 (FIG. 4, near the bottom portion) is facing the light channel C. In addition, a light absorbing material 140 may be applied on the part of the surface 340 facing the light channel C. Thus, when the light L1 transmitted in the light channel C is incident on the surface 340, the light L1 will be absorbed by the light absorbing material 140 rather than reflected by the surface 340 to form stray light. In other embodiments, the entire surface of the surface 340 may be coated with the light absorbing material 140. In addition to being coated on the surface 340, the light absorbing material 140 may also be coated on other surfaces of the diffractive component 300 except the diffractive surface 310 such as, for example, those surfaces on which the light L1 may be incident.

FIG. 5A is a perspective view of a spectrometer in accordance with yet another embodiment of the present invention. FIG. 5B is an exploded perspective view of the spectrometer of FIG. 5A. FIG. 5C is a perspective view of the heightening component of the spectrometer of FIG. 5A. Referring to FIGS. 5A-5C, the spectrometer 100b of the present embodiment is similar to the spectrometer 100 shown in the FIGS. 1A and 1B, and the major difference between the two is the difference between the heightening components 130b and 130. In FIGS. 5A and 5B, in order to allow the reader to clearly see the internal structure of the spectrometer 100b, the case 214 of the first base body 210 (shown in FIG. 1A) is removed. The shape of the reflective plate 216 in FIG. 5A may be used as a reference for the three-dimensional shapes of the reflective plates 216 and 226 in FIG. 1A, and the shape of the case 224 in FIG. 5A may be used as a reference for the three-dimensional shape of the case 224 in FIG. 1A. In the present embodiment, the case 224 may be produced by, for example, a computer numerical control (CNC) system. In the present embodiment, the heightening component 130b includes at least one light confinement groove 134b (FIG. 5C shows a plurality of light confinement grooves 134b as an example) located on a surface 133b of the heightening component 130b that faces the light channel C. The position of the surface 133b with respect to the light channel C is essentially identical to the position of the surface 133 of the heightening component 130 with respect to the light channel C in FIG. 1C. The difference between the surface 133b and the surface 133 is that the surface 133b has light confinement grooves 134b while the surface 133 is a flat surface. Therefore, similar to the heightening component 130, beside the surface 133b of the heightening component 130b, there is also a light output channel A. In the present embodiment, after passing through the light input port 120, a portion of the light L1 is diffracted by the diffractive surface 310, another portion of the light L1 exits the light channel C via the light output channel A, and the remaining portion of the light L1 is trapped by the light confinement groove(s) 134b.

Light L1 incident on the at least one light confinement groove 134b is repeatedly reflected by each of the at least one light confinement groove 134b and is confined within the at least one light confinement groove 134b. Specifically, each light confinement grooves 134b may have two opposed inclined guide surfaces 1342 connected by an annular-shaped reflective surface 1344 with a notch 1343 thereon. Light L1 incident on the surface 133b will be reflected by the inclined guide surfaces 1342 and enters into the space surrounded by

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the annular-shaped reflective surface **1344** via the notch **1343**. Since the dimension of the notch **1343** is smaller than that of the space defined by the annular-shaped reflective surface **1344**, light **L1** in the space will be repeatedly reflected by the annular-shaped reflective surface **1344**, making the escape of the light very difficult. Since every reflection will cause a slight attenuation of the light intensity, after multiple reflections light **L1** will be absorbed by the annular-shaped reflective surface **1344** and disappear within the space. In this way, the light confinement groove(s) **134b** can avoid formation of stray light, thus enhancing the quality of the spectra measured by the light sensor **110**.

In the present embodiment, the heightening component **130b** includes position reference marks **1345** and **1346**, which can serve as the references for the relative position of the diffractive component **300** and the heightening component **130b**. The position reference marks **1345** and **1346** may be openings. Specifically, as shown in FIG. 5A, when the diffractive component **300** is disposed on the heightening component **130b**, an assembler can determine whether the diffractive component **300** is positioned correctly based on a ratio of the position reference marks **1345** and **1346** covered by the diffractive component **300**. After the diffractive component **300** is determined to be in the correct position, the diffractive component **300** can be fixed, or otherwise secured, by an adhesive material. The adhesive material may be applied to the reflective plate **226** or the case **224** (please refer to FIG. 1A), situated below the openings (i.e., the position reference marks **1345** and **1346**), through these openings, thereby fixing or securing the relative positions of the diffractive component **300**, the heightening component **130b**, and the second base body **220** (shown in FIG. 1A).

Furthermore, in the present embodiment, the reference marks **1345** and **1346** may extend in different directions such as, for example, in substantially mutually perpendicular directions. In this way, when judging whether the diffractive component **300** is correctly positioned, reference marks in two different directions can be used as the reference points. In addition, the heightening component **130b** may include a positioning unit **2242** such as, for example, a positioning post. When the heightening component **130b** is disposed on the reflective plate **226**, the positioning unit **2242** may be inserted in the positioning hole **135**, for example, so that the positioning portion **2242** is tightly fit in the positioning hole **135**. In this way, the heightening component **130b** can be secured.

In the present embodiment, the heightening component **130b** also includes slits **1362**, **1364** and **1366**. The slit **1362** connects the reference mark **1345** to the reference mark **1346**, and the slit **1364** connects the reference mark **1346** to the positioning hole **135**. The slit **1366** extends through a side of the heightening component **130b**, connecting the positioning hole **135** to the space outside the side of the heightening component **130b**. As a result, the heightening component **130b** can be formed simply by cutting once with a cutting tool when the heightening component **130b** is formed by cutting a plate-shaped material. In addition, when the heightening component **130b** is mounted on the positioning unit **2242** through the slit **1366**, the positioning hole **135** can be slightly enlarged by the positioning unit **2242** so as to enable easy assembly of the heightening component **130b** on the positioning unit **2242** while still maintaining the tight fit effect. In another embodiment, as shown in FIG. 6, the heightening component **130c** may include slits **1362** and **1364**, but not the slit **1366** of FIG. 5C. This design allows the heightening component **130c** to be formed by cutting twice with the cutting tools. Alternatively, in other embodiments, no slits **1262**

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and **1364** are provided in the heightening component **130c**, and accordingly the heightening component **130c** may be formed by cutting multiple times.

Referring to FIGS. 5A to 5C again, the spectrometer **100b** of the present embodiment also includes an adapter **150** and a mask component **160**. The adapter **150** is configured to connect to one end of a light fiber while the other end of the light fiber receives the to-be-measured light **L1** from the light source. When the light **L1** is transmitted to the adapter **150** via the light fiber and then incident on the mask component **160** via an opening **152** of the adapter **150**, a portion of the light **L1** can be transmitted to the light channel **C** via the light input port **120** since the light input port **120** is formed on the mask component **160** (as shown in FIG. 1A, for example, as a slit). However, in other embodiments, there would be no adapter **150** in the spectrometer **100b**. A portion of the light **L1** to be measured is directly incident on the light input port **120**, and then transmitted to the light channel **C** via the light input port **120**.

FIG. 7 a perspective view of a diffractive component and a heightening component in accordance with another embodiment of the present invention. Referring to FIG. 7, the heightening component **130d** of the present embodiment is similar to the heightening component **130** shown in FIG. 1C. Differences between the two are described below. In the spectrometer of the present embodiment, the heightening member **130d** includes multiple spacers **131d** that are spaced apart with respect to each other. These spacers **131d** are located between the diffractive component **300** and the second base body **220**. The spacers **131d** may be transparent or light absorbing to reduce the formation of stray light. Moreover, these spacers **131d** may be disposed on a part of the diffractive component **300** so as to form a light output channel **A** along a side of the spacers **131d**, thereby reducing the formation of stray light.

FIG. 8 is a side view of a spectrometer in accordance with still another embodiment of the present invention. Referring to FIG. 8, the spectrometer **100e** of the present embodiment is similar to the spectrometer **100** shown in FIG. 1A. Differences between the two are described below. Referring to FIG. 8, unlike the spectrometer in FIG. 1A where the heightening component **130** is used to raise the height of the diffractive component **300**, the spectrometer **100e** of the present embodiment includes an adhesive material **130e** that secures the diffractive component **300** to at least one of the first base body **210** and the second base body **220** (in the example shown in FIG. 8, the diffractive component **300** is secured to the second base body **220**). In the present embodiment, the adhesive material **130e** is, for example, adhesive glue. A part of the adhesive material **130e** is provided between the diffractive component **300** and the reflective plate **226** so that the diffractive component **300** is attached to the reflective plate **226**. In addition, another part of the adhesive material **130e** is applied to the reflective plate **226**, the case **224**, and the diffractive component **300**. The diffractive component **300** may be secured by the adhesive material **130e** at a suitable height, so that the first side **312** of the diffractive surface **310** is positioned between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222**. As a result, the diffraction effect of the diffractive component **300** is enhanced.

FIG. 9 is a partial sectional side view of a spectrometer in accordance with another embodiment of the present invention. Referring to FIG. 9, the spectrometer **100f** of the present embodiment is similar to the spectrometer **100** shown in FIG. 1A. Differences between the two are described below. In the present embodiment, at least one of the first base body **210f**

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and the second base body **220f** of the waveguide module **200f** includes a fixing component (in the example shown in FIG. 9, the first base body **210f** has a fixing component **215f** on the case **214f** and the second base body **220f** has a fixing component **225f** on the case **224f**) to secure the position of the diffractive component **300**. Specifically, the fixing component **215f** and fixing component **225f** may be, for example, convex portions. The diffractive component **300** may be held between the fixing component **225f** and the elastic fixing component **215f** disposed on the case **214** to achieve the effect of securing the diffractive component **300**. In the present embodiment, the fixing component **215f** is made of, for example, elastic silicone. The diffractive component **300** is fixed to a suitable height by the elastic fixing component **215f** and the fixing component **225f** such that the first side **312** of the diffractive surface **310** is positioned between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222** with a spacing or gap maintained between the first side **312** of the diffractive surface **310** and the second reflective surface **222**. This design enhances the diffraction effect of the diffractive component **300**.

In other embodiments, the fixing component may be provided on the first base body **210f** instead and not on the second base body **220f**, or each of the first base body **210f** and the second base body **220f** is respectively provided with a fixing component, so that the diffractive component **300** can be fixed to a suitable height to enhance the diffraction effect. In addition, in other embodiments, other components or structures may be adopted to secure the diffractive component **300** to a suitable height so that the first side **312** of the diffractive surface **310** is positioned between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222**. These components and structures are all within the scope of protection of the present invention.

FIG. 10 is a side view of a spectrometer in accordance with yet another embodiment of the present invention. Referring to FIG. 10, the spectrometer **100g** of the present embodiment is similar to the spectrometer **100** shown in FIG. 1A. Differences between the two are described below. Referring to FIG. 10, the waveguide module **200g** of the spectrometer **100g** in the present embodiment includes a light guiding body **230**, a first reflective film **216g**, and a second reflective film **226g**. The light guiding body **230** forms a light channel C. The first reflective film **216g** is disposed on the light guiding body **230**, and the second reflective film **226g** is disposed on the light guiding body **230**. The light guiding body **230** is disposed between the first reflective film **216** and the second reflective film **226**. An interface between the first reflective film **216g** and the light guiding body **230** forms the first reflective surface **212**, and an interface between the second reflective film **226g** and the light guiding body **230** forms the second reflective surface **222**. The light guiding body **230** is made of, for example, a transparent material such that light **L1** can be transmitted within the light guiding body **230** and continuously reflected by the first reflective film **216g** and the second reflective film **226g**. The first reflective film **216g** and the second reflective film **226g** may be, for example, a metal coated film or a non-metal coated film. In other words, the light guiding body **230**, the first reflective film **216g**, and the second reflective film **226g** together form a solid waveguide. In other embodiments, the waveguide module **200g** may include a light guiding body that can guide light by total reflection, and Light **L1** can be transmitted within the light guiding body through total internal reflection. As a result, there is no need to form reflective films by further processing.

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In the present embodiment, the heightening component **130g** is disposed on the case **224** to locate the diffractive component **300** at a suitable height, and to allow the first side **312** of the diffractive surface **310** to be positioned between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222**. As a result, the diffraction effect of the diffractive component **300** is enhanced. In other embodiments, an adhesive material, a fixing component on the case **214** or case **224**, or any other component or structure on which the diffractive component **300** can be secured may be employed to position the first side **312** of the diffractive surface **310** between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222**.

FIG. 11 is a side view of a spectrometer in accordance with still another embodiment of the present invention. Referring to FIG. 11, the spectrometer **100h** of the present embodiment is similar to the spectrometer **100** disclosed in FIG. 1A. Differences between the two are described below. In the present embodiment, the diffractive surface **310** of the notch **305** on the diffractive component **300** of the spectrometer **100h** is inclined relative to the bottom surface **330**. Specifically, when a semiconductor material is etched using the semiconductor etching process, the processing conditions may result in an undercut, thus the bottom surface **330** becomes the end surface of etching. As a result, the diffractive surface **310** will be inclined relative to the bottom surface **330**. In the present embodiment, the bottom surface **330** is inclined relative to the second reflective surface **222** so that the diffractive surface **310** is generally parallel with the normal vector of the second reflective surface **222**. Specifically, when the undercut occurs, the diffractive surface **310** is not perpendicular to the second reflective surface **222**. In order to have the diffractive surface **310** positioned nearly perpendicular to the second reflective surface **222**, the diffractive component **300** is tilted, i.e., the bottom surface **330** is tilted. In this way, light **L1** can be incident on the diffractive surface **310** approximately perpendicularly. As a result, the diffraction effect (i.e., resolution) can be enhanced.

In the present embodiment, the heightening member **130h** may be disposed between the diffractive component **300** and the second base body **220** and away from one side of the diffractive surface **310** of the diffractive component **300**, i.e., below the end of the diffractive component **300**. In this way, the end of the diffractive component **300** will be raised up to tilt the bottom surface **330** and to position the diffractive surface **310** nearly vertically.

FIG. 12 is a side view of a spectrometer in accordance with another embodiment of the present invention. Referring to FIG. 12, the spectrometer **100i** of the present embodiment is similar to the spectrometer **100h** disclosed in FIG. 11. Differences between the two are described below. In the present embodiment, except that the diffractive surface **310** of the notch **305** on the diffractive component **300** of the spectrometer **100i** is inclined relative to the bottom surface **330**, the first side **312** of the diffractive surface **310** is also located between the first reflective surface **212** and the second reflective surface **222** in a direction perpendicular to the second reflective surface **222**. Thus, in addition to the fact that light **L1** may be perpendicularly incident on the diffractive surface **310**, a portion of the light **L1** with higher intensity may be incident on the portion of the strip-shaped diffractive structures **320** with sharper profile (as shown in FIG. 1C). In this way, the diffractive surface **310** can better diffract light **L1** and enhance the optical quality of the resulting spectra.

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In the present embodiment, the heightening component **130i** not only increases the height of the diffractive component **300** but also tilts the diffractive component **300**. For example, one side of the heightening component **130i** that is further away from the diffractive surface **310** has a thickness greater than the other side that is closer to the diffractive surface **310**, thus achieving heightening and tilting effects at the same time.

In addition to utilizing the heightening component **130h** of FIG. **11** and the heightening component **130i** of FIG. **12** as described above to set the diffractive component **300** at an optimal position and angle, in other embodiments, an adhesive material or other components or structures may also be used to adjust the position and angle of the diffractive component.

FIGS. **13A** to **13E** are diagrams illustrating an assembling system in accordance with one embodiment of the present invention to explain the associated assembling procedure. Referring to FIGS. **13A** to **13E**, the assembling method in the present embodiment can be used to assemble the spectrometer **100e** as shown in FIG. **8** or other spectrometers described above. Hereafter, the assembly of the spectrometer **100e** disclosed in FIG. **8** is described as an example. The method for assembling a spectrometer in the present embodiment includes the following steps. First, as shown in FIG. **13A**, a waveguide module **200** is provided. For example, a carrier **410** in an assembling system **400** may be used to carry the waveguide module **200**. Then, as shown in FIG. **13B**, the diffractive component **300** is disposed adjacent to the light channel **C** (as shown in FIG. **1A**), for example, by a first fixture **420** in the assembling system **400**. Next, as shown in FIG. **13C**, the light sensor **110** is disposed on one end of the light channel **C**, for example, by a second fixture **430** in the assembling system **400**. Thereafter, light **L1** is transmitted to the diffractive surface **310** via the light channel **C** such that at least a portion of the light **L1** is diffracted by the diffractive surface **310** and then transmitted to the light sensor **110**. For example, light **L1** from a light source **450** is transmitted to the diffractive surface **310** after passing through the light input port **120** and the light channel **C** sequentially. In the present embodiment, the light source **450** may be a standard lamp of known spectral radiance and/or intensity.

Then, either or both the position of the diffractive surface **310** along a direction substantially perpendicular to the second reflective surface **222** (e.g., direction **D1**) and an angle $\theta 1$ between the diffractive surface **310** and the second reflective surface **222** (as shown in FIG. **8**) is adjusted, and the corresponding spectrum of the light **L1** incident on the light sensor **110** is measured. For example, the first fixture **420** may be used to adjust either or both the position of the diffractive surface **310** along a direction substantially perpendicular to the second reflective surface **222** and angle $\theta 1$ between the diffractive surface **310** and the second reflective surface **222**. The first fixture **420** may achieve this effect by shifting or rotating the diffractive component **300**.

In the present embodiment, the first fixture **420** may also be used to adjust the position of the diffractive surface **310** along a direction that is substantially parallel to the second reflective surface **222** and substantially perpendicular to a straight line connecting the light input port **120** (as shown in FIG. **1A**) and the diffractive surface (e.g., direction **D2**). The light input port **120** is provided on one end the waveguide module **200**, for example, on the mask component **160**. Moreover, in the present embodiment, the first fixture **420** may also be used to adjust the distance between the diffractive surface **310** and the light input port **120** (e.g., a distance along a direction parallel to direction **D3**). Moreover, in the present embodiment, the

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first fixture **420** may be used to adjust a first rotation angle $\theta 2$ of the diffractive surface of **310**. The first rotation angle $\theta 2$ is defined as an angle around an axis **A2** that is substantially parallel to the normal vector of the second reflective surface **222**. Furthermore, in the present embodiment, the first fixture **420** may be used to adjust a second rotation angle $\theta 3$ of the diffractive surface **310**. The second rotation angle $\theta 3$ is defined as an angle around an axis **A3** that is substantially parallel to a straight line connecting the light input port **120** and the diffractive surface **310**.

In this way, the first fixture **420** may adjust not only the position of the diffractive surface **310** in three directions **D1**, **D2** and **D3**, but also the angle $\theta 1$, the first rotation angle $\theta 2$, and the second rotation angle $\theta 3$ of the diffractive surface **310**. Accordingly, the first fixture **420** is capable of performing six-axis adjustments to the diffractive component **300**.

Afterwards, referring to FIG. **13D**, it is determined whether the spectrum of the light **L1** measured by the light sensor **110** meets a predefined first sharpness condition. If the spectrum of the light **L1** measured by the light sensor **110** meets the predefined first sharpness condition, the diffractive component **300** is secured. Otherwise, at least one of position and angle of the diffractive surface **310** will be adjusted until the first sharpness condition is met. Specifically, whether the spectrum meets the predefined first sharpness condition is determined by a control unit **490** (as shown in FIG. **13E**). When the spectrum meets the predefined first sharpness condition, an adhesive material **442** is applied to the diffractive component **300** by an adhesive dispenser **440** in the assembling system **400** so as to fix or secure the diffractive component **300** on at least one of the first base body **210** and the second base body **220**. FIG. **13D** shows the example of the diffractive component **300** being fixed on the reflective plate **226** of the second base body **220**. In the present embodiment, the adhesive dispenser **440** is controlled, for example, by the control unit **490**. In addition, in the present embodiment, the predefined first sharpness condition may be, for example, a predefined spectral sensitivity or a predefined spectral resolution having a value greater than a preset threshold within a specified wavelength range.

Furthermore, in the present embodiment, the position and the angle used to obtain the spectrum in a previous measurement may be used to determine the adjustment of at least one of the position and angle of the diffractive surface **310** in a current measurement.

Next, referring to FIG. **13E**, after the diffractive component **300** is secured, either or both of position and angle of the light sensor **110** relative to the light channel **C** is adjusted, and the corresponding spectrum of the light **L1** incident on the light sensor **110** is measured. Subsequently, it is determined whether the spectrum of the light **L1** incident on the light sensor **110** meets a predefined second sharpness condition. If the condition is met, the light sensor **110** is secured. Otherwise, the adjustment of either or both of position and angle of the light sensor **110** relative to the light channel **C** will be continued until the condition is met. In the present embodiment, the predefined second sharpness condition may be, for example, a predefined spectral sensitivity or a predefined spectral resolution having a value greater than a preset threshold within a specified wavelength range. The first sharpness condition and the second sharpness condition may be the same or different depending on the requirements.

Specifically, either or both of position and angle of the light sensor **110** can be adjusted by a second fixture **430** that is similar to the first fixture **420**. Moreover, in the present embodiment, the second fixture **430** can move the light sensor **110** in three directions, namely a direction parallel to the light

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channel C, a direction perpendicular to the light channel C and the second reflective surface 222, and a direction perpendicular to the light channel C but parallel to the second reflective surface 222. Alternatively, the second fixture 430 can rotate the light sensor 110 around three rotation axes, namely a rotation axis parallel to the light channel C, a rotation axis perpendicular to the light channel C and the second reflective surface 222, and a rotation axis perpendicular to the light channel C but parallel to the second reflective surface 222. In other words, in the present embodiment, the second fixture 430 is capable of performing six-axis adjustments to adjust the position of the light sensor 100. Furthermore, in the present embodiment, when the spectrum measured by the light sensor 110 meets the second sharpness condition, an adhesive material 462 is applied to the light sensor 110 by the adhesive dispenser 460 in the assembling system 400 so as to secure the light sensor 110 on one end of the light channel C, for example, on one or both of the first base body 210 and the second base body 220.

Referring to FIG. 13E, the assembling system 400 further includes a first actuator 470, a second actuator 480, and a control unit 490. The first actuator 470 drives the first fixture 420, and the second actuator 480 drives the second fixture 430. The control unit 490 is electrically connected to the first actuator 470 and the second actuator 480 to control the actions of the first actuator 470 and the second actuator 480. In other words, the first actuator 470 and the second actuator 480 can drive the first fixture 420 and the second fixture 430, respectively, to adjust positions and angles of the diffractive component 300 and the light sensor 110, respectively. Moreover, the way that the first actuator 470 drives the first fixture 420 and that the second actuator 480 drives the second fixture 430 is subject to the control of the control unit 490. The control unit 490 is, for example, a control chip, a processor, a computer, or another appropriate controller.

In the present embodiment, the control unit 490 is electrically connected to the light sensor 110 and the adhesive dispensers 440 and 460. The light sensor 110 sends signals of measured spectral back to the control unit 490. The control unit 490 determines either or both of the position and angle of the diffractive component 300, as well as either or both of the position and angle of the light sensor 110, based on these spectral signals. The control unit 490, through a determination process, determines whether the sharpness of the spectral signals measured by the light sensor 110 meets preset standards (e.g., the first sharpness condition and the second sharpness condition). When the standards are met, the control unit 190 commands the adhesive dispenser 440 to apply the adhesive material onto the diffractive component 300. Otherwise, the control unit 190 commands the first actuator 470 and second actuator 480 to adjust either or both of the position and angle of the diffractive component 300, or either or both of the position and angle of the light sensor 110, until the sharpness of the spectral signals meets the standards.

In addition, in the present embodiment, the control unit 490 may also be electrically connected to the adhesive dispenser 460. When the control unit 490 determines that the spectrum measured by the light sensor 110 meets the second sharpness condition, the control unit 490 commands the adhesive dispenser 460 to apply the adhesive material onto the light sensor 110 so as to secure the position and angle of the light sensor 110.

After the diffractive component 300 and the light sensor 110 are secured with the adhesive material using the procedures described above, the first side 312 of the diffractive surface 310 is positioned between the first reflective surface 212 and the second reflective surface 222 in a direction per-

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pendicular to the second reflective surface 222 with a spacing or gap maintained between the second reflective surface 222 and the first side 312. Alternatively, the diffractive surface 310 is positioned to be substantially parallel with the normal vector of the second reflective surface 222. Alternatively, the diffractive surface 310 is positioned in the above-mentioned two positions simultaneously. Thus, a spectrometer having good spectral qualities can be obtained, according to the assembling method and the assembling system 400, such as the spectrometer 100e, for example, and variations thereof (such as the one with an inclined bottom surface 330) may be obtained.

In the present embodiment, the example given involves securing the light sensor 110 after the diffractive component 300 is secured. However, in another embodiment, the diffractive component 300 and the light sensor 110 may be secured with the adhesive material after positions of both the diffractive component 300 and the light sensor 110 has been adjusted (i.e., both of the first sharpness condition and the second sharpness condition are met, where the first sharpness condition and the second sharpness condition may be the same or different). During the adjustment of the positions of the diffractive component 300 and the light sensor 110, various combinations of the relative positions of the diffractive component 300 and the light sensor 110 may be generated. The control unit 490 may store the information related to the spectral senility, the spectral resolution and the ratio of stray light of the spectra of these combinations measured by the light detector 110 in a data storage medium. In addition, the control unit 190 may select one or more of the combinations having optimal spectral signals, so that in subsequent assemblies, the control unit 190 may first position the diffractive component 300 and the light sensor 110 at specific positions according to the one or more selected combinations. Alternatively, the control unit 190 may perform an interpolative estimation of the positions of the diffractive component 300 and the light sensor 110 in advance according to these combinations, thus effectively shortening the assembly time.

The description above pertains to an example of an automatic mode through which the positions of the diffractive component 300 and the light sensor 110 are adjusted. However, in other embodiments, positions of the diffractive component 300 and the light sensor 110 may also be adjusted manually. When manual adjustment is adopted, the first fixture 420 and the second fixture 430 are replaced by manually-operated fixtures. The manually-operated fixtures may include at least one sliding rail and at least one rotating lever. In the present embodiment, when the position of the diffractive component 300 or the light sensor 110 is to be adjusted along the six axes, the first fixture 420 may be replaced with three sliding rails and three rotating levels, and the second fixture 430 may also be replaced with three sliding rails and three rotating levels. For example, the three sliding rails may be used to adjust the positions of the diffractive surface 310 along three directions D1, D2, and D3, respectively, while the three rotating levers can be used to adjust the angle θ_1 , the first rotation angle θ_2 , and the second rotation angle θ_3 of the diffractive surface 310, respectively.

In addition, when manual adjustment is used, an example illustrating a method to adjust the light sensor 110 and determine whether the spectrum meets the predefined sharpness condition is described below. Firstly, a mercury lamp may be used as the light source 450. Then, the position of the light sensor 110 is adjusted along a direction perpendicular to the second reflective surface 222 and the light channel C by observing whether the peak of the spectrum is long and thin. When the peak value reaches the highest and the peak shape

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becomes the longest and the thinnest, the light sensor **110** will be set at this position. The peak value is the number of counts of the spectrum representing the light energy received by the light sensor **110**. When the light sensor **110** continuously receives the light **L1** within an integrated time period, the number of counts will be increased as time elapses. Therefore, the determination of whether the peak value reaches the highest is based on whether the number of counts of the peak value reaches the maximum with respect to those at other wavelengths. In other words, the number of counts of the spectrum can be viewed as the relative intensity of light at different wavelengths.

Next, the position of the light sensor **110** is adjusted along a direction substantially parallel to the light channel **C**, i.e., the distance between the light sensor **110** and the diffractive component **300** is adjusted. After the peak value of each wavelength in the spectrum becomes the largest and at the same time the peak shape at each wavelength becomes elongated, and before some of the peak values increase and some of the peak values decrease, the light sensor **110** is set at this position.

Afterwards, the position of the light sensor **110** is secured. In this way, the light sensor **110** can be secured at a position with a relatively better spectral resolution and a relatively high peak value. The same procedure may be followed to move or rotate the light sensor **110** along or around other directions.

Moreover, the above-described procedure for adjusting the position of the light sensor **110** and determining whether a sharper spectrum is obtained may be applied to the diffractive component **300**. Furthermore, in order to shorten the assembly time, the diffractive component may also be first moved or rotated to a limited number of specified positions based on prior adjustments, and then the sharpness of each of corresponding spectra is determined. The diffractive component **300** is then secured at one position with the sharpest spectrum. In this way, the diffractive component **300** only needs to be adjusted at fewer positions and angles to observe the corresponding spectra rather than being continuously adjusted at various positions and angles during observation of the spectra. By doing so, assembly time can be effectively shortened. In other words, the position and the angle of the diffractive component **300** only need to be roughly adjusted. After the diffractive component **300** is secured, the position and angle of the light sensor **110** are fine-tuned. Accordingly, the spectrum with high spectral quality can still be obtained.

After the light sensor **110** is secured, a halogen lamp may be used as the light source **450**, and some wavelengths of the light **L1** measurable by the light sensor **110** may be filtered out by the filter. Next, the number of counts of those wavelengths being filtered out may be compared to the number of counts of unfiltered wavelengths, and the ratio of these counts may be used to determine the influence of stray light on the light sensor **110**. A larger ratio normally indicates a greater effect of stray light.

Next, a light source with calibrated intensity of light may be used as the light source **450**, which may be used to calibrate the intensity of light measured by the light sensor **110**.

FIG. **14A** is a side view of a spectrometer in accordance with a further embodiment of the present invention. FIG. **14B** is a top view of the spectrometer of FIG. **14A** with the case **214** removed. FIG. **14C** is a perspective view of the spectrometer of FIG. **14A** with the case **214** removed. Referring to FIGS. **14A** to **14C**, the spectrometer **100j** of the present embodiment is similar to the spectrometer **100** shown in FIG. **1A**. Differences between the two are described below. In the present embodiment, the spectrometer **100j** also includes a

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connecting unit **505j** connecting the diffractive component **300** to the first base body **210**. Since the diffractive component **300** is connected to the first base body **210** by the connecting unit **505j**, when temperature changes of the spectrometer **100j** result in deformation (e.g., increase in width and length) of the first base body **210**, changes will also occur on the diffractive component **300** through the connecting unit **505j**. When the position of the diffractive component **300** changes with the deformation of the first base body **210**, the connection between the diffractive component **300** and the first base body **210** or the strength of the connection is less susceptible to thermal stress. In this way, the reliability and durability of the spectrometer **100j** can be effectively improved.

In the present embodiment, the connecting unit **505j** connects the diffractive component **300** to the reflective plate **216**. When temperature changes cause deformation of the reflective plate **216** of the spectrometer **100j**, changes will also occur on the diffractive component **300** via the connecting unit **505j**. When the position of the diffractive component **300** changes with the deformation of the reflective plate **216**, the connection between the diffractive component **300** and the reflective plate **216** or the strength of the connection is less susceptible to damage by thermal stress.

In the present embodiment, the connecting unit **505j** includes a fixing component **510j** and multiple pieces of an adhesive material **520j**. The fixing component **510j**, having multiple first through holes **512j**, is disposed on the first base body **210**. A first portion **512j/1** of the first through hole **512j** exposes a part of the diffractive component **300**, and a second portion **512j/2** of the first through holes **512j** exposes a part of the first base body **210** (in the present embodiment, a part of the reflective plate **216** is exposed; in other embodiments, a part of the case **214** may be exposed). The first through holes **512j** are filled with the adhesive material **520j**. The adhesive material **520j** in the first portion **512j/1** of the first through holes **520j** connects the fixing component **510j** to the diffractive component **300**, while the adhesive material **520j** in the second portion **512j/2** of the first through holes connects the fixing component **510j** to the first base body **210**. In the present embodiment, the fixing component **510j** is, for example, a fixing plate disposed on the reflective plate **216**. However, in other embodiments, the fixing plate **510j** may be disposed on the case **214**.

In the present embodiment, the connecting unit **505j** also includes a gasket **130j**, which has at least one second through hole **132j**, located between the diffractive component **300** and the fixing component **510j** (in the example of FIG. **14A** multiple second through holes **132j** are shown). Each of the second through holes **132j** is interlinked with a corresponding first through hole **512j/1**. Some of the pieces of the adhesive material **520j** are filled in the first through holes **512j/1** and the second through holes **132j** to connect the fixing component **510j**, the gasket **130j**, and the diffractive component **300** together.

In the present embodiment, the first through holes **512j/1** are distributed at different locations, and the quantity of the first through holes **512j/1** is at least three. This allows the adhesive material **520j** filled in the first through holes to provide a better control over the degree in which the diffractive component **300** is leveled horizontally or inclined. However, in other embodiments, one first through hole **512j/1** is provided.

In addition, in the present embodiment, the connecting unit **505j** may include at least one positioning hole **530j** (in the example of FIG. **14C** multiple positioning holes **530j** are shown) extending through the diffractive component **300** and

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the gasket 130j, and exposing a part of the upper surface 360 of the diffractive component 300. When using the adhesive material 520j to secure the diffractive component 300, a gasket is disposed between the reflective plate 226 and the diffractive component 300 first, and then the fixture is abutted against the surface 360 of the diffractive component 300 through the positioning hole 530j so as to temporarily secure the position of the diffractive component 300. Subsequently, the adhesive material 520j is filled into the first through hole 512j1 and the second through hole 132j. The diffractive component 300 is secured after the adhesive material 520j is cured. At this point, the gasket is removed from the reflective plate 226 and the diffractive component 300; meanwhile, the fixture may also be removed from the positioning hole 530j.

In this way, the diffractive component 300 is secured above the second base body 220 with a spacing or gap in between. By doing so, stray light can exit the spectrometer 100j through the spacing between the diffractive component 300 and the second base body 220. It noteworthy that in the present embodiment, the allocation surface 350 of the diffractive component 300 facing the reflective plate 226 may be coated with a reflective material to form a mirror. As a result, stray light can more easily exit the spectrometer 100j via the spacing between the diffractive component 300 and second base body 220. In other words, in the present embodiment, the positioning may be achieved by the fixing component 510j, the gasket 130j and the adhesive material 520j. The position and the degree of inclination of the diffractive surface 310 may be controlled by the thickness and the degree of inclination of the lower surface of the gasket 130j, respectively.

In the present embodiment, the fixing component 510j, the gasket 130j and the reflective plate 216 are made of metal such as, for example, aluminum. The adhesive material 520j is, for example, a UV curable adhesive, an AB glue or another adhesive material. Because the thermal expansion coefficient of metal is smaller than that of the adhesive material, when the adhesive material 520j is attached to the inner walls of the first through hole 512j1 and the second through hole 132j, the expansions of the fixing component 510j and the gasket 130j under heat are smaller. As a result, the fixing component 510j and the gasket 130j can effectively limit the expansion of the adhesive material 520j. In this way, the height of the diffractive component 300 in a direction perpendicular to the first reflective surface 212 is less susceptible to ambient temperature changes.

In the present embodiment, the fixing component 510j and the reflective plate 216 may be made of the same material or different materials as long as the thermal expansion coefficients of the fixing component 510j and the reflective plate 216 are substantially the same. Thus, when the length or the width of the reflective plate 216 increases due to ambient temperature changes, the fixing component 510j can react to these changes, thereby producing a corresponding deformation. As a result, the position of the diffractive component 300 is changed correspondingly to minimize possible damage due to thermal stress caused by the connection between the diffractive component 300 and the reflective plate 216. However, in other embodiments, the thermal expansion coefficient of the fixing component 510j may be different from that of the reflective plate 216.

In other embodiments, when the diffractive component 300 is thick enough, no gasket 130j is needed. The diffractive component 300 may be abutted against the fixing component 510j directly.

FIG. 15 is a side view of a spectrometer in accordance with another embodiment of the present invention. Referring to FIG. 15, the spectrometer 100k of the present embodiment is

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similar to the spectrometer 100j shown in FIG. 14A. Differences between the two are described below. In the spectrometer 100k of the present embodiment, the diffractive component 300k is secured to a side 2162 of the reflective plate 216 by the connecting unit 505k. Specifically, the connecting unit 505k, an adhesive material for example, is used to affix the diffractive component 300k to the reflective plate 216. Such construction allows the position of the diffractive component 300k to be shifted corresponding to the expansion or contraction of the reflective plate 216. Accordingly, the connection between the diffractive component 300k and the reflective plate 216 is less susceptible to damage by thermal stress.

FIG. 16 is a top view of a spectrometer with a case partially removed in according with yet another embodiment of the present invention. Referring to FIG. 16, the spectrometer 100m of the present embodiment is similar to the spectrometer 100e shown in FIG. 8. Differences between the two are described below. In the spectrometer 100m of the present embodiment, the diffractive component 300 has a backside 370 opposite to the diffractive surface 310. The backside 370 is connected to the second base body 220 by an adhesive material 130m (the example of FIG. 16 shows the backside 370 connected to the reflective plate 226 of the second base body 220), thus securing the diffractive component 300 to the second base body 220. In addition, in the present embodiment, no adhesive material 130m is applied to a side surface 380 of the diffractive component 300 that connects the backside 370 with the diffractive surface 310. In this way, when there is a significant change in the ambient temperature, the position of the diffractive component 300 can vary by a larger margin, thus the connection between the diffractive component 300 and the second base body 220 is less susceptible to damage by thermal stress. In another embodiment, the side surface 380 of the diffractive component 300, connecting the backside 370 and the diffractive surface 310, may be coated with the adhesive material 130m.

In summary, in the spectrometers in accordance with the various embodiments of the present invention, since the first side of the diffractive surface is positioned between the first reflective surface and the second reflective surface in a direction perpendicular to the second reflective surface, a portion of light transmitted in the light channel that has higher intensity will be diffracted by the part of the diffractive surface having a sharper profile. As a result, the optical quality of the spectra measured by the spectrometer can be enhanced. In the spectrometers in accordance with the embodiments of the present invention, since the bottom surface of the notch of the diffractive component is inclined relative to the second reflective surface, the diffractive surface is generally parallel with the normal vector of the second reflective surface. As a result, the optical quality of the spectra obtained can be enhanced. In the methods for assembling spectrometers in accordance with the embodiments of the present invention, since the diffractive component is secured after either or both of the position and angle of the diffractive component has been adjusted and after the spectrum obtained has been determined to be sharp, the diffractive component can be secured at a suitable position. As a result, the optical quality of the spectra obtained can be enhanced. In the assembling system in accordance with the embodiments of the present invention, since the first fixture and the second fixture are adopted to adjust the relative positions of the diffractive component and the light sensor, respectively, the relative positions of the diffractive component and the light sensor can be accurately adjusted. As a result, the optical quality of the spectra obtained can be enhanced.

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From the foregoing it would be appreciated that, although specific embodiments of the present invention have been described for purpose of illustration, by no means they are to be interpreted as limiting the scope of the present invention. Various modifications may be made without departing from the spirit and scope of the present invention. Accordingly, the scope of the present invention is to be determined entirely by the following claims.

What is claimed is:

1. A spectrometer, comprising:
 - a waveguide module, the waveguide module having a first reflective surface, a second reflective opposite to the first reflective surface, and a light channel located between the first reflective surface and the second reflective surface;
 - a diffractive component, the diffractive component having a diffractive surface with a plurality of strip-shaped diffractive structures, wherein a sharpness of a profile of the strip-shaped diffractive structures at a first side of the diffractive surface is greater than a sharpness of the profile of the strip-shaped diffractive structures at a second side of the diffractive surface, wherein the first side of the diffractive surface is located between the first reflective surface and the second reflective surface, with the first side of the diffractive surface spaced apart from both the first and the second reflective surfaces, when viewed along a direction generally perpendicular to the second reflective surface; and
 - a light sensor, the light sensor receiving diffracted light after light transmitted in the light channel is diffracted into the diffracted light by the diffractive surface.
2. The spectrometer of claim 1, wherein the waveguide module comprises:
 - a first base body having the first reflective surface; and
 - a second base body having the second reflective surface, wherein:
 - the light channel is formed between the first base body and the second base body, and
 - the diffractive component is disposed on at least one of the first base body or the second base body.
3. The spectrometer of claim 2, further comprising a heightening component disposed between the diffractive component and at least one of the first base body or the second base body.
4. The spectrometer of claim 3, further comprising a light input port, wherein at least a part of light entering into the spectrometer via the light input port is transmitted within the light channel to the diffractive surface of the diffractive component.
5. The spectrometer of claim 4, wherein a light output channel is formed between the diffractive component and the second base body, wherein the light output channel is adjacent to the heightening component, wherein a part of the light entering into spectrometer via the light input port exits the light channel via the light output channel.
6. The spectrometer of claim 3, wherein the heightening component and the diffractive components are formed integrally.
7. The spectrometer of claim 3, wherein the heightening component comprises a plurality of spacers spaced apart with respect to each other in a direction substantially parallel to the second reflective surface.
8. The spectrometer of claim 3, wherein the heightening component has a light absorbing surface.
9. The spectrometer of claim 3, wherein the heightening component comprises a transparent component.

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10. The spectrometer of claim 3, wherein the heightening component comprises at least one light confinement groove, located on a surface of the heightening component facing the light channel, such that light entering into the at least one confinement groove is repeatedly reflected by and confined in the at least one light confinement groove.

11. The spectrometer of claim 3, wherein the heightening component comprises at least one position reference mark that indicates relative positions of the diffractive component and the heightening component.

12. The spectrometer of claim 3, wherein the second base body comprises:

- a case; and
- a reflective plate disposed on the case, wherein a surface of the reflective plate is provided as the second reflective surface, and wherein the heightening component is disposed on the reflective plate.

13. The spectrometer of claim 3, wherein the second base body comprises:

- a case; and
- a reflective plate disposed on the case, wherein a surface of the reflective plate is provided as the second reflective surface, and wherein the heightening component is disposed on the case.

14. The spectrometer of claim 1, wherein the waveguide module comprises:

- a first base body having the first reflective surface; and
- a second base body having the second reflective surface, wherein:
 - the light channel is formed between the first base body and the second base body, and
 - an adhesive material, the adhesive material securing the diffractive component to at least one of the first base body or the second base body.

15. The spectrometer of claim 14, wherein the diffractive component has a backside opposite to the diffractive surface, wherein the adhesive material connects the backside of the diffractive component to the second base body such that the diffractive component is secured on the second base body.

16. The spectrometer of claim 1, wherein the waveguide module comprises:

- a first base body having the first reflective surface; and
- a second base body having the second reflective surface, wherein:
 - the light channel is formed between the first base body and the second base body, and
 - at least one of the first base body or the second base body includes a fixing component that secures a position of the diffractive component.

17. The spectrometer of claim 1, wherein the waveguide module comprises:

- a light guiding body provided as the light channel;
- a first reflective film disposed on the light guiding body; and
- a second reflective film disposed on the light guiding body such that the light guiding body is between the first reflective film and the second reflective film, wherein:
 - an interface between the first reflective film and the light guiding forms the first reflective surface, and
 - an interface between the second reflective film and the light guiding body forms the second reflective surface.

18. The spectrometer of claim 1, wherein the diffractive component comprises a notch having a bottom surface and the diffractive surface, wherein the diffractive surface is inclined relative to the bottom surface, wherein the bottom surface is inclined relative to the second reflective surface

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such that the diffractive surface is approximately parallel with a normal vector of the second reflective surface.

19. The spectrometer of claim 1, wherein the strip-shaped diffractive structures are substantially parallel with respect to each other, and wherein the diffractive surface is a curved concave surface.

20. The spectrometer of claim 1, wherein the diffractive component comprises:

a notch having a respective diffractive surface and a bottom surface connected to the respective diffractive surface; and

a surface connected to the bottom surface, wherein at least a portion of the surface faces the light channel and is coated with a light absorbing material.

21. The spectrometer of claim 1, wherein the diffractive surface is formed by etching started from the first side of the diffractive surface.

22. The spectrometer of claim 1, further comprising a positioning means for setting a position of the first side of the diffractive surface such that the first side of the diffractive surface is spaced apart from the second reflective surface when viewed from a direction perpendicular to the second reflective surface.

23. The spectrometer of claim 1, wherein the diffractive component comprises:

a notch having a respective diffractive surface and a bottom surface connected to the respective diffractive surface; and

an allocation surface connected to the respective diffractive surface of the notch, the allocation surface facing the second reflective surface and coated with a reflective material.

24. The spectrometer of claim 1, wherein the waveguide module comprises:

a first base body having the first reflective surface; and a second base body having the second reflective surface, wherein:

the light channel is formed between the first base body and the second base body, and

the spectrometer further comprises:

a connecting unit that connects the diffractive component to the first base body of the waveguide module, wherein a deformation of the first base body due to a temperature change in the spectrometer causes a change in a dimension of the diffractive component.

25. The spectrometer of claim 24, wherein the connecting unit comprises:

a fixing component disposed on the first base body, the fixing component having a plurality of first through holes, a first part of the first through holes exposing a portion of the diffractive component, a second part of the first through holes exposing a portion of the first base body; and

a plurality of pieces of an adhesive material filled in the first through holes, some of the pieces of the adhesive material filled in the first part of the first through holes connecting the fixing component to the diffractive component, some other pieces of the adhesive material filled in the second part of the first through holes connecting the fixing component to the first base body.

26. The spectrometer of claim 25, wherein the connecting unit comprises a gasket disposed between the diffractive

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component and the fixing component, the gasket having at least one second through hole interlinked with the first part of the first through holes such that the first part of the first through holes and the at least one second through hole are filled with the adhesive material to connect the fixing component, the gasket, and the diffractive component together.

27. The spectrometer of claim 24, wherein the first base body comprises:

a case; and

a reflective plate disposed on the case and having the first reflective surface, wherein the connecting unit connects the diffractive component and the reflective plate, and wherein a deformation of the reflective plate due to a temperature change in the spectrometer causes a change in a dimension of the diffractive component through the connecting unit.

28. The spectrometer of claim 27, wherein the reflective plate has a side to which the diffractive component is secured by the connecting unit, and wherein the connecting unit comprises an adhesive material.

29. A spectrometer, comprising:

a waveguide module, the waveguide module having a first reflective surface, a second reflective surface opposite to the first reflective surface, and a light channel located between the first reflective surface and the second reflective surface;

a diffractive component, the diffractive component having an allocation surface and a notch located on a side of the allocation surface, wherein the notch includes a diffractive surface and a bottom surface that is separated from the allocation surface, wherein the diffractive surface is inclined relative to both the allocation surface and the bottom surface such that a first angle is formed between the diffractive surface and the allocation surface and a second angle is formed between the diffractive surface and the bottom surface, wherein neither the first angle nor the second angle is substantially a right angle, wherein the allocation surface is not substantially parallel to a normal vector of the second reflective surface but is inclined relative to the second reflective surface such that the diffractive surface is generally parallel with the normal vector of the second reflective surface, and wherein the allocation surface is connected with the diffractive surface through a continuous edge of the diffractive surface; and

a light sensor, the light sensor receiving diffracted light after light transmitted in the light channel is diffracted into the diffracted light by the diffractive surface.

30. The spectrometer of claim 29, wherein the waveguide module comprises:

a first base body having the first reflective surface; and a second base body having the second reflective surface, wherein:

the light channel is formed between the first base body and the second base body, and

the diffractive component is disposed on at least one of the first base body or the second base body.

31. The spectrometer of claim 30, further comprising a heightening component disposed between the diffractive component and the second base body and disposed on a side of the diffractive component away from the diffractive surface.

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